Forecast Applications Branch Briefing

For Scott Hausman

Dec 5, 2012

OUTLINE

- Introduction – Zoltan Toth 15 mins

- Review of major areas of work
  - Observing systems – Yuanfu Xie, Seth Gutman 15 mins
  - Data assimilation – Yuanfu Xie 15 mins
  - Numerical forecasting – Ligia Bernardet 15 mins
  - Products – Paula McCaslin 15 mins
  - Transition to operations – Ligia Bernardet 15 mins

- Around the table – FAB personnel 30 mins

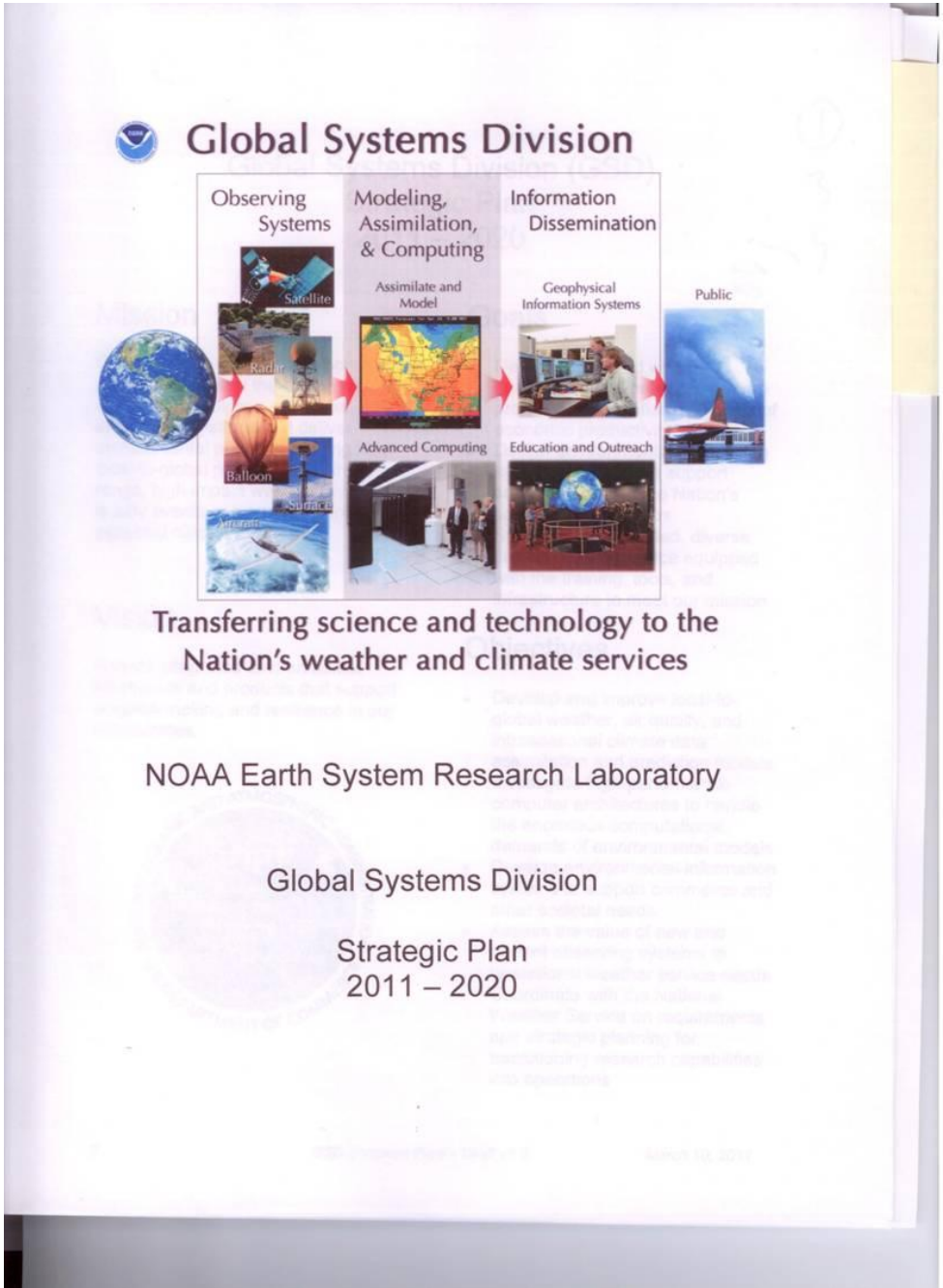
WHAT WE DO?

- Research & development in selected areas
- Transition of mature results into operations

HOW TOPICS SELECTED?

- NOAA (or other agencies, industry) need it - fills a gap/need
- Lines up with NOAA's, OAR's, and GSD's Strategic Plans
- Large anticipated impact (on science, applications, operations)
- Potentially big return for our investment - bang for the buck
- Work is innovative, leads to a unique contribution
- We have the right skill set and experience – people available
- We are prepared in general - we have tools etc in place
- Partners (collaborators, customers, etc) are ready to engage
- Can potentially transition to operations
- Work fits in with rest of our portfolio – leveraging opportunities
- Other groups may not be as well positioned to lead effort
- Funding is available or likely can be secured

GSD STRATEGIC PLAN



GSD STRATEGIC PLAN - FAB

Forecast Applications Branch

Plans for the Forecast Applications Branch (FAB) for the next 10 years include topics under five major themes listed below. Work will be carried out in collaboration with others both within and outside of GSD. A significant part of the work will be directed toward major NOAA programs and initiatives such as aviation-related weather (NextGen), hurricanes (HFIP), fire weather, and heavy precipitation (the Hydrometeorological Testbed) forecasting.

Observing systems

To help NOAA realize its 20-year vision of advanced real-time observational systems coupled with forecast models, FAB will develop comprehensive OSSE capabilities that can address questions ranging from local-to-global scales. FAB will stress the optimal design of existing and planned observing systems for improved convective initiation and other high-impact service sector needs. Provided that it is carefully designed, the OSSE framework can be used not only to evaluate future observing systems, but also to better understand the effectiveness of various techniques in data assimilation.

Following recommendations from the recent ESRL Physical Sciences Review, we will expand our research activities related to both satellite data calibration and validation and derived product evaluation using various in situ observing systems. FAB will continue research related to the ground-based GPS-Met observing system. In addition, efforts will be made to develop reliable estimates of observational errors for other remotely and in situ-sensed data types for their improved use in data assimilation and model verification.

Data assimilation

FAB will continue to address the predictability of the onset, duration, and impact of high-impact weather events by emphasizing the accurate depiction of the initial conditions, especially of moisture-related variables for local to regional applications. The Space-Time Multiscale Analysis System (STMAS) will be developed into a four-dimensional variational technique to capture the variability of moisture and other variables. STMAS is a sophisticated variational approach that can contribute temporal weighting and multigrid, situation-dependent background error covariances to the NCEP GSI. This work will be conducted in close collaboration with NCEP and AMB. Our foci will include the best choice for analysis control variables and forward operators for new observing systems such as remote sensors on unmanned aircraft and polarimetric radar. Our research will also address the proper initialization of cloud microphysical parameters, improved ensemble-based estimates of background error covariance, and methods for non-linear and non-Gaussian applications. These and other improvements will address the goal of creating well balanced initial conditions for forecasting the moist dynamics needed for accurate, very short-range forecasting of convective initiation and for other critical applications.

Ensemble forecasting

NOAA's Five-year Research Plan encourages researching ways to "provide decision-support services based upon probabilistic model guidance." Ensemble forecasting techniques, where multiple

NWP forecasts are made to reflect forecast uncertainty associated with errors and approximations in initial conditions and model formulation, are at the core of advanced probabilistic forecast methods. FAB will expand its current ensemble-related research efforts and will lead the design and implementation of the DTC Ensemble Testbed. In collaboration with AMB, high-priority topics include:

- *New methods for capturing the nonlinear and non-Gaussian nature of analysis errors in initial ensemble perturbations*
- *Research into the best ways of linking data assimilation and initial ensemble perturbation generation methods*
- *Estimation of forecast error covariance*
- *Innovative ways for assessing and representing model-related uncertainty*

Statistical postprocessing

The NOAA Five-year Research Plan highlights the need to "reduce uncertainty associated with weather and water - decision tools … [via] better ensemble and statistical postprocessing techniques." FAB will partner with NCEP/EMC to expand its research aimed at improved statistical methods for: removing lead time-dependent bias from gridded NWP forecasts, downscaling coarser resolution forecasts to a finer grid, and combining all forecast information available from various high-resolution unperturbed and coarser-resolution ensemble forecasts into a single consolidated and unified set of statistically bias-corrected and downscaled set of ensemble forecasts. The latter topic is an essential component of the 4D Cube. Focus areas for statistical postprocessing will include: exploration of Bayesian methodologies for bias correction, statistical-dynamical downscaling to represent subgrid-scale variability, bias correction of positional errors, and other statistical postprocessing methods.

Applications

In general, the emphasis in NOAA is shifting from products to services. Our research will respond to these challenges in two primary areas: (1) enhancements to data analysis systems to further improve portability and timeliness, and (2) creation of toolkits and applications to fully exploit the potential of the 4D Cube. Our plans are to address net-enabled user access to advanced analysis systems such as STMAS, thus providing users with on-demand generation of analysis products and very short-range numerical guidance utilizing all available observations anywhere with adequate internet access. Interrogation and product display tools will be developed allowing forecasters and automated decision-support tools to ask any weather-related question, and be provided with probabilistic and other types of information based on the statistically-corrected and processed ensemble data contained in the 4D Cube. In coordination with NWS, FAB will also design, develop, and test high-level forecast modification tools that forecasters can use efficiently. Based on simple input (e.g., change in first and/or second moment of the distribution of one variable at one time in the Cube ensemble), the tools will intelligently spread the forecaster input ("increment") across variables, space, and time to modify the entire distribution of ensemble data, based on forecast covariance information derived from the ensemble data itself.

ORGANIZATION

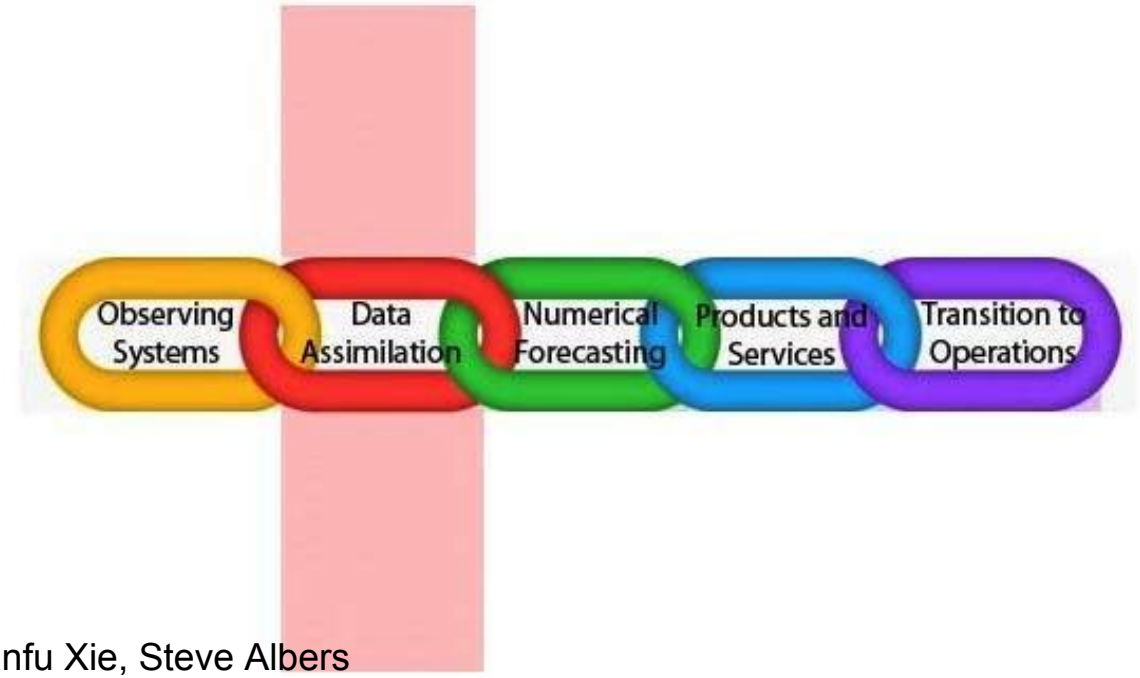
- 5 Thrust Areas
  - Various levels of base funding

- Numerous funded projects
  - Map onto one or more thrust areas, e.g.
    - HMT / CA-DWR: Observing system, data assimilation, numerical forecasting, products
  - Led by key contributors

FAB Thrust Areas

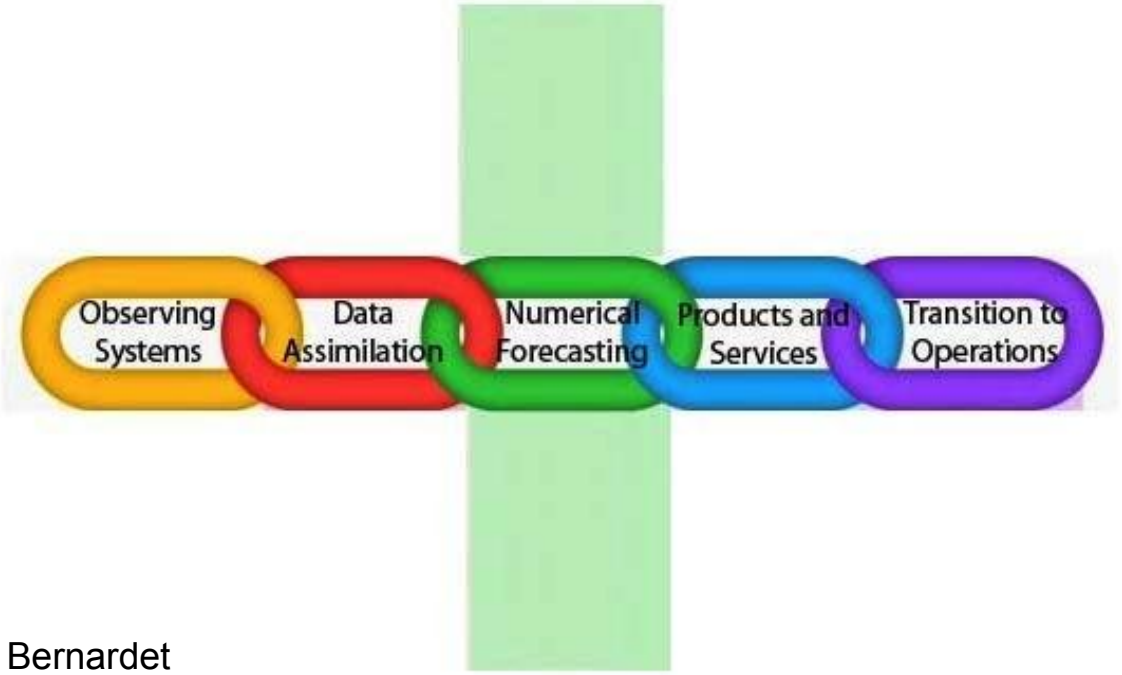
Lead: Seth Gutman, Yuanfu Xie

FAB Thrust Areas



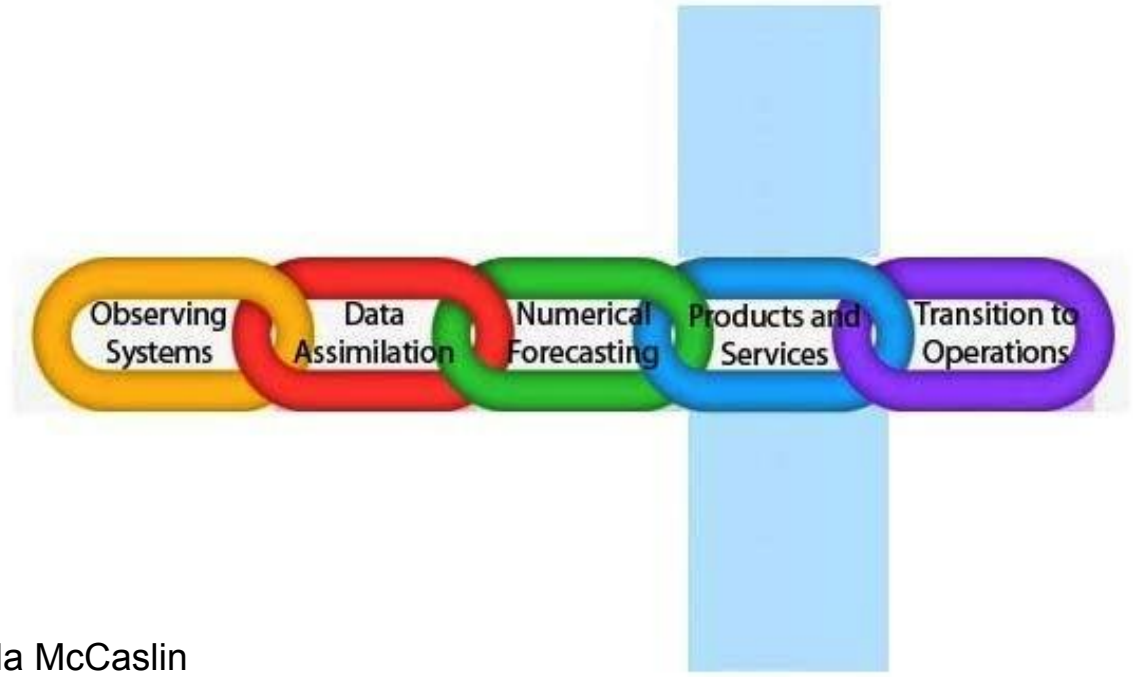
Lead: Yuanfu Xie, Steve Albers

FAB Thrust Areas



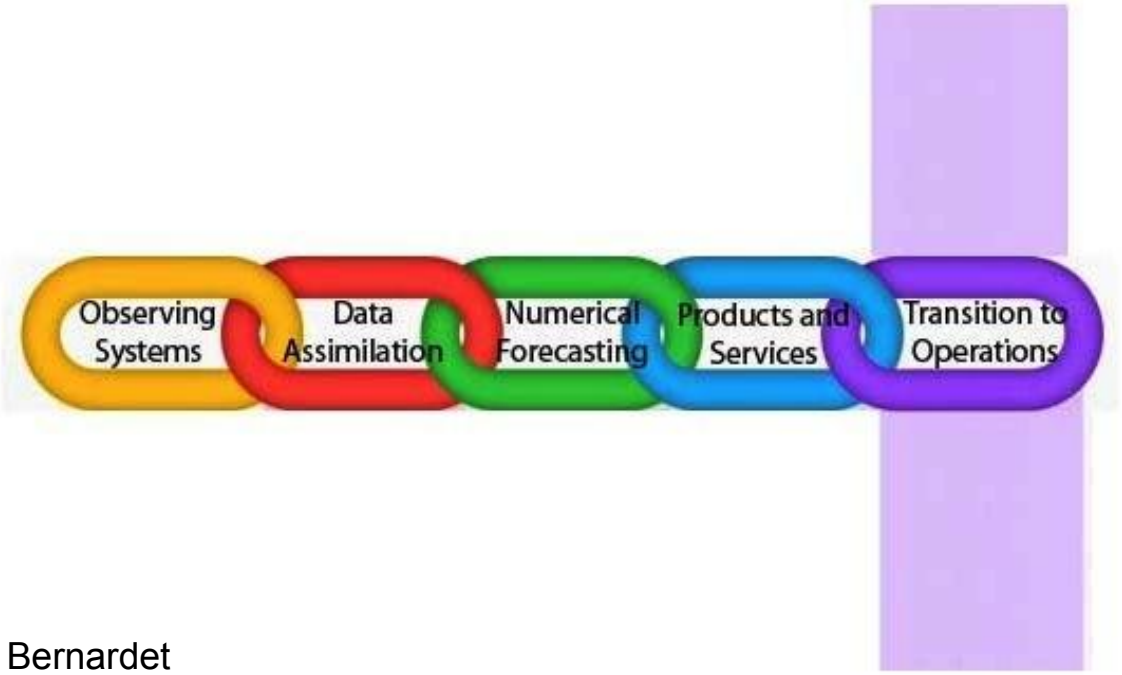
Lead: Ligia Bernardet

FAB Thrust Areas



Lead: Paula McCaslin

FAB Thrust Areas



Lead: Ligia Bernardet

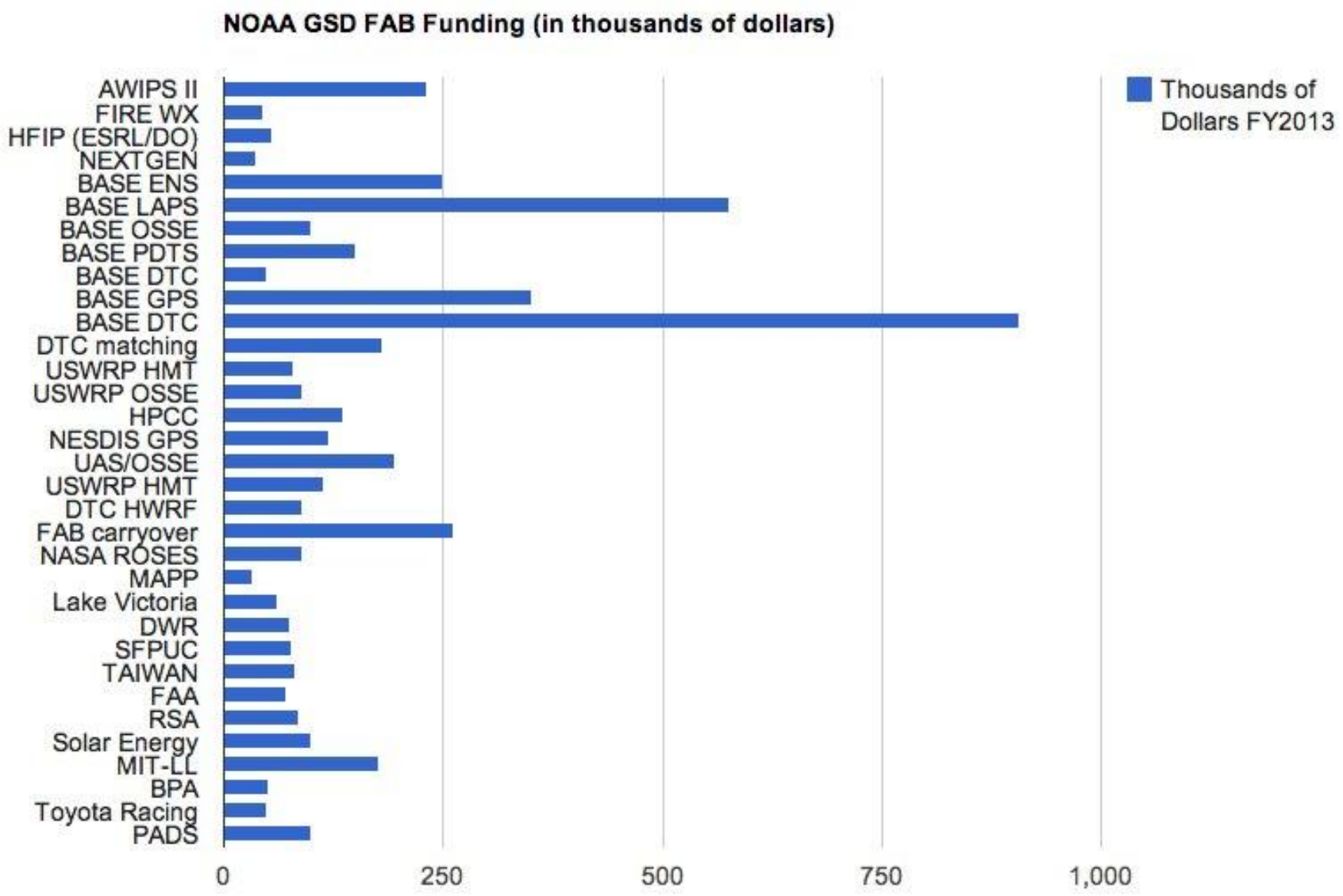
FAB Staff

- Federal
  - Dan Birkenheuer*
  - Seth Gutman
  - Kirk Holub
  - Paula McCaslin
  - Paul Schultz
  - Linda Wharton
  - Yuanfu Xie
- Contract
  - Scott Buennemeyer

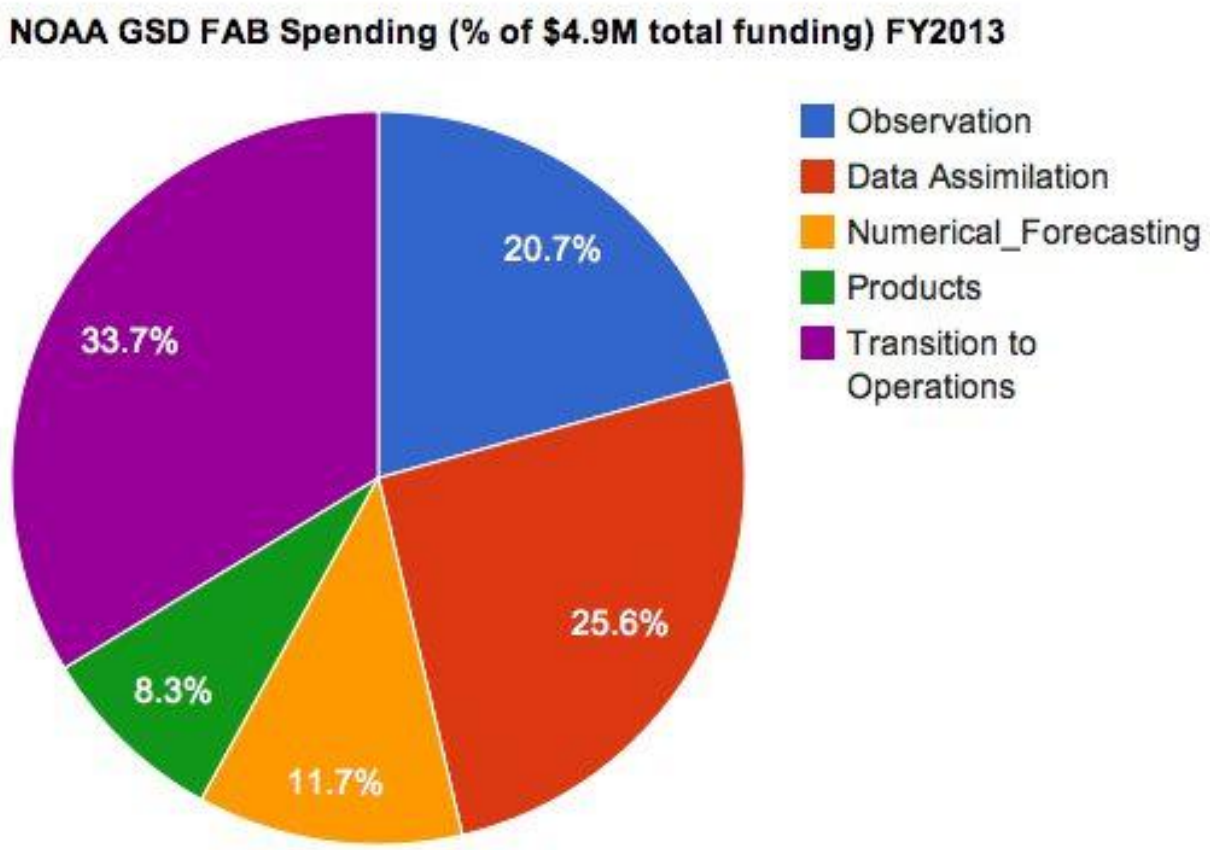
- Coop Institute - CIRA
  - Steve Albers
  - Hongli Jiang
  - Ed Tollerud (Part Time)
- Coop Institute - CIRES
  - Shaowu Bao
  - Ligia Bernardet
  - Tim Brown
- Visitors
  - Yu Zhang (long-term)
  - Mrinal Biswas (weekly)

* CIRA Fellow

FAB Funding Sources



FAB Spending Categories



FAB Website

http://esrl.noaa.gov/gsd/fab/

Forecast Applications Branch

Earth System Research Laboratory
Global Systems Division

Search ESRL: Search
Calendar | People | Publications

FAB About Staff Focus Areas Realtime Products

Intranet
GSD Topics
GSD Branches
ESRL Divisions

Forecast Applications Branch (FAB) is one of five branches in NOAA's Global Systems Division (GSD).

FAB's expertise is in weather forecasting application and solutions. This work group creates tools that allow scientists to get more information from observations and simulated observations, cunduct weather analysis and numerical forecasting, including ensemble forecasting, and more.

FAB Areas of Focus and Accomplishment

Observing Systems | Data Assimilation | Numerical Forecasting | Products and Services | Transition to Operations

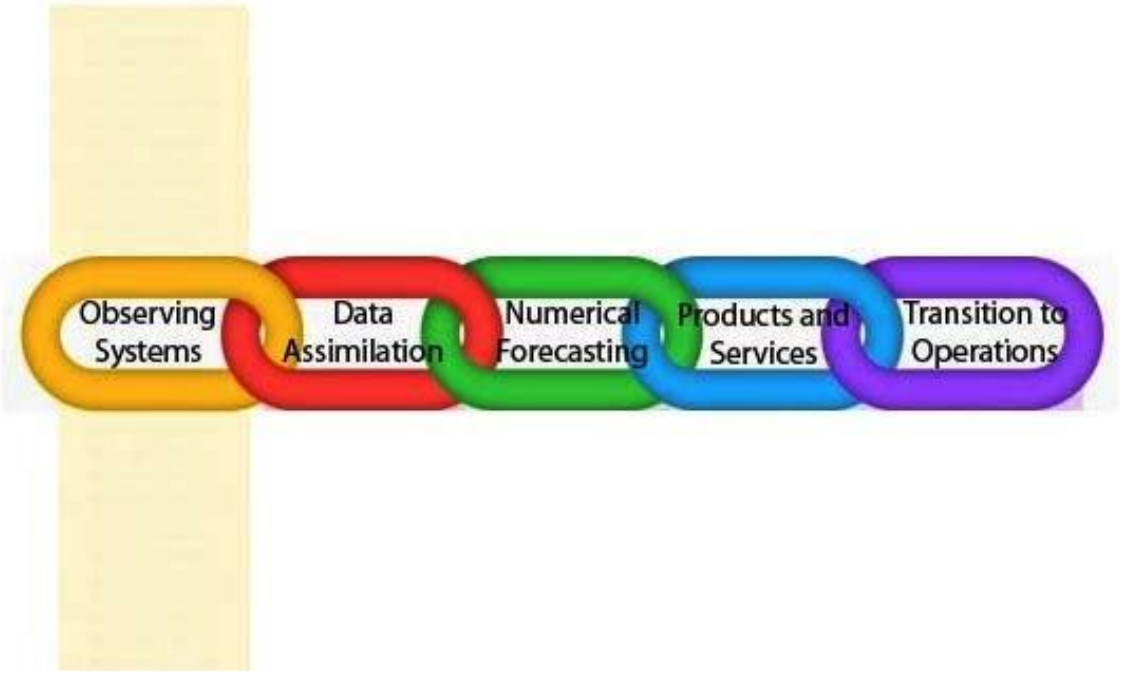
FAB is involved in using and developing observing systems and simulated observing systems. An OSSE is a modeling experiment used to evaluate the impact of new observing systems on operational forecasts when actual observational data is not available

Observation Simulation System Experiments (OSSE) – Evaluation of new observation technology or siting of existing observational systems. This system has been employed to assess the potential of new satellite systems for instrument placement around eastern and western space centers of the U.S. Air Force and spaceborne wind lidar systems for NOAA. This includes the study of the Windsor Tornado event.

GPS-Met Observing Systems (GPS-Met) – The goals of the GPS-Met Observation System project are to assess the use of surface-based GPS observations to support weather forecasting, climate monitoring, and research, and to transfer this observing system technology to operational use. An operational ground-based GPS integrated precipitable water vapor (IPW) monitoring system would provides water vapor measurements at a low cost and without weather condition and time-of-day constraints.

Satellite Products – involve the utilization and evaluation of raw radiances and products derived from GOES atmospheric soundings, for the purpose of developing a complete national-scale moisture analysis useful for high-resolution model initialization. The branch also participates in the Joint Center for Satellite Data Assimilation. Image

Simulated Observing Systems



What is an OSSE?

(Observing System Simulation Experiments)

An OSSE is a modeling experiment used to evaluate the impact of new observing systems on operational forecasts *when actual observational data is not available*.

- A long free model run is used as the “truth” - the Nature Run
- The Nature Run fields are used to back out “synthetic observations” from all current and new observing systems.
- The synthetic observations are assimilated into a different operational model
- Forecasts are made with the second model and compared with the Nature Run to quantify improvements due to the new observing system

Early OSSE works confirmed data impact when observation systems have actually launched (ERS, NSCAT and AIRS, Atlas 1985,1997).

Observation System Simulation Experiment

- Goal
  - Study effect of changes in observing systems on quality of NWP analyses & forecasts
    - Predict impact of planned observing systems before actual deployment
    - Optimize (quality vs cost) mix of existing observing systems
- Approach
  - Simulate nature & observing, DA, NWP forecast systems
  - Study data impact in simulated world
- Tools
  - Best DA, NWP systems available
  - Simulated nature
    - To draw observations from
- Simulation of nature
  - Integration with a high resolution NWP model
    - With a model different from that used by NWP system used in simulations

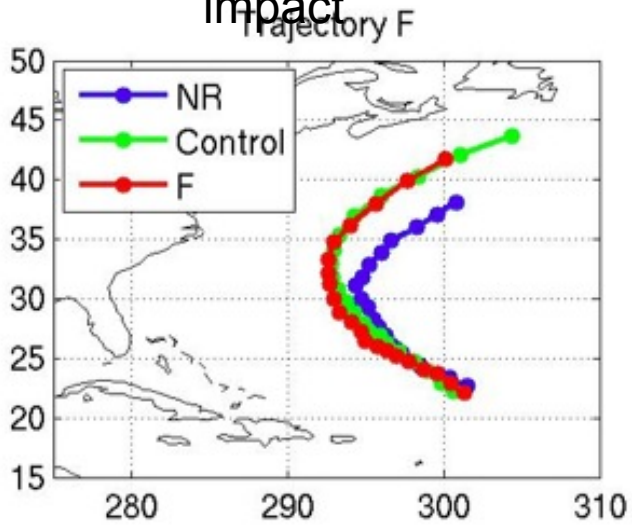
NOAA OSSE testbed

- OSSE provides a unique tool evaluating future observation needs and observation system before they are launched;
- OSSE provides a cost-benefit evaluation for optimally design future observation system;
- NOAA needs a OSSE testbed for satellite data, UAS, WISDOM, and Lidar for meeting societal needs;
- NOAA is preparing to form an OSSE testbed;
- GSD objectives are within the testbed scope, UAS, WISDOM and ATM satellite datasets.

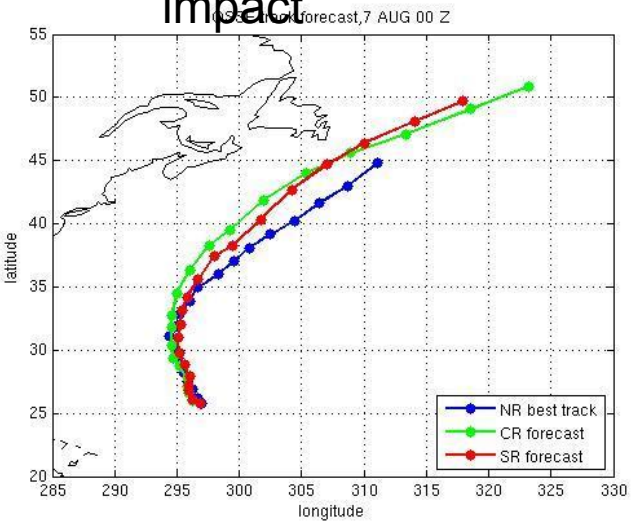
GSD OSSE

- Calibrated NOAA joint OSSE;
- Report to NOAA UAS program on UAS data impact on hurricane tracks;
- A journal paper to Tellus on joint OSSE calibration;
- WISDOM OSSE;
- New nature run;
- Targeting observation scheme in OSSE.

UAS impact

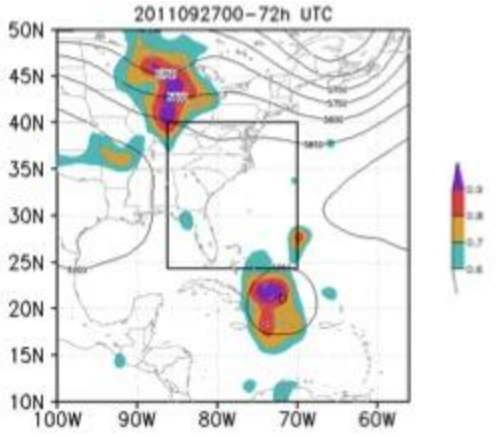


WISDOM impact



Targeting Observation Progress

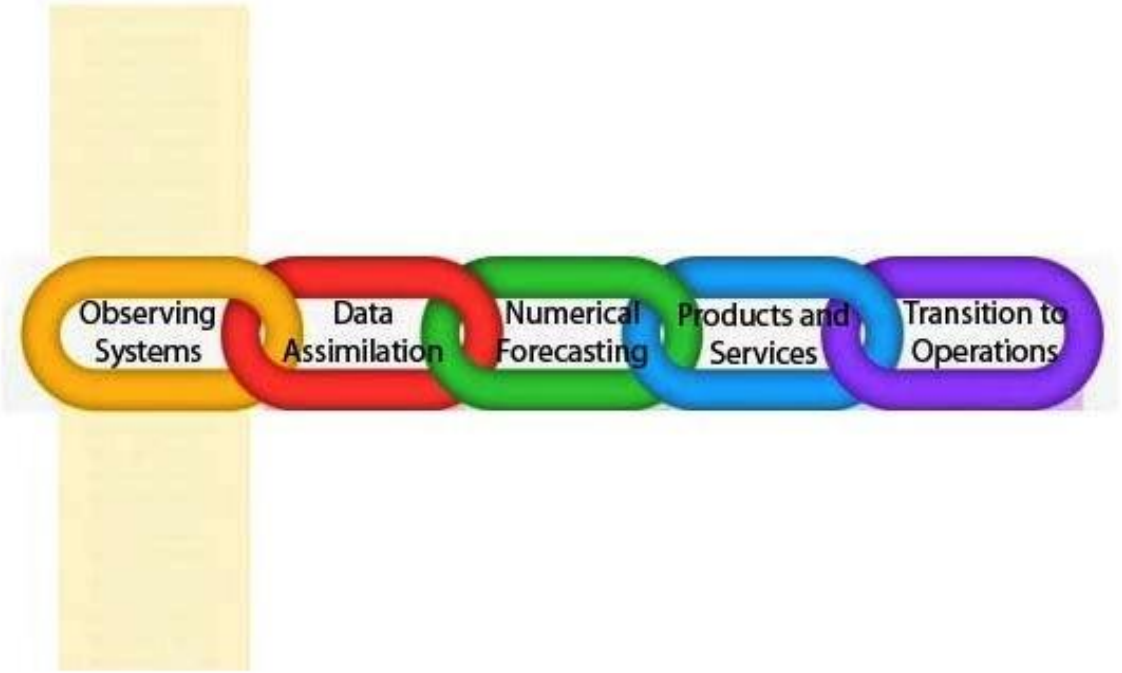
- Yu Zhang from CMA helps OSSE porting targeting observation scheme
- Plan to use a nudged nature run for a WISDOM OSSE
- Hurricane Irene is used as the new nature run almost identical to reality;
- Observation sensitive areas identified



Future OSSE Work

- UAS OSSE on hurricane tracks (joint OSSE)
- UAS OSSE on atmospheric river (joint OSSE or new regional OSSE) related to HMT/USWRP projects
- WISDOM (depending on funding)
- Possible future hyper-spectral satellite data impact comparing to the retiring polar orbiting satellite
- Recent call on OSSE study for meeting NOAA data gap mitigation study

FAB Observing Systems



GPS Met – Background

- GPS Met project became part of GSD/OD when NOAA Profiler Program transferred to NWS in 2006.
- GPS Met was finally assigned to FAB in 2008.

Sustain GPS Met Data & Products to Research & Operations

- 537 locations worldwide
- 325-350 PW estimates to NCEP every 30-min.
- Some uses:
  - NWP
  - Regional fcst
  - Raob/Acft QC
  - Blended TPW products
  - GOES product development and satellite Cal/Val
  - HMT/AR observ-atories

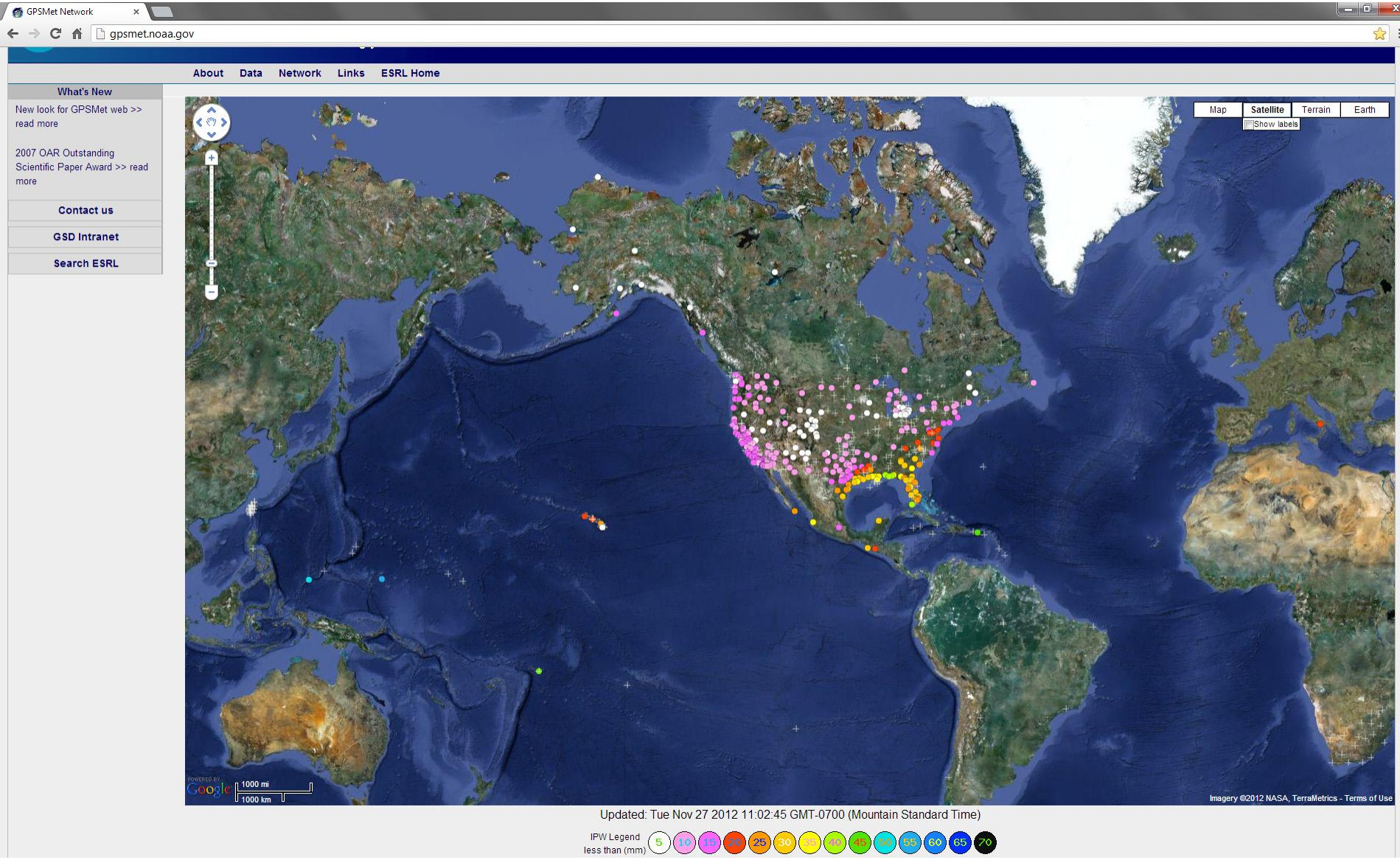
Transition GPS Met from Research to Operations

- LOA between OAR, NESDIS & NWS to produce a BCA and transition plan
- Stalled because of reassignments and shifting priorities
- Recommendation: re-prioritize.

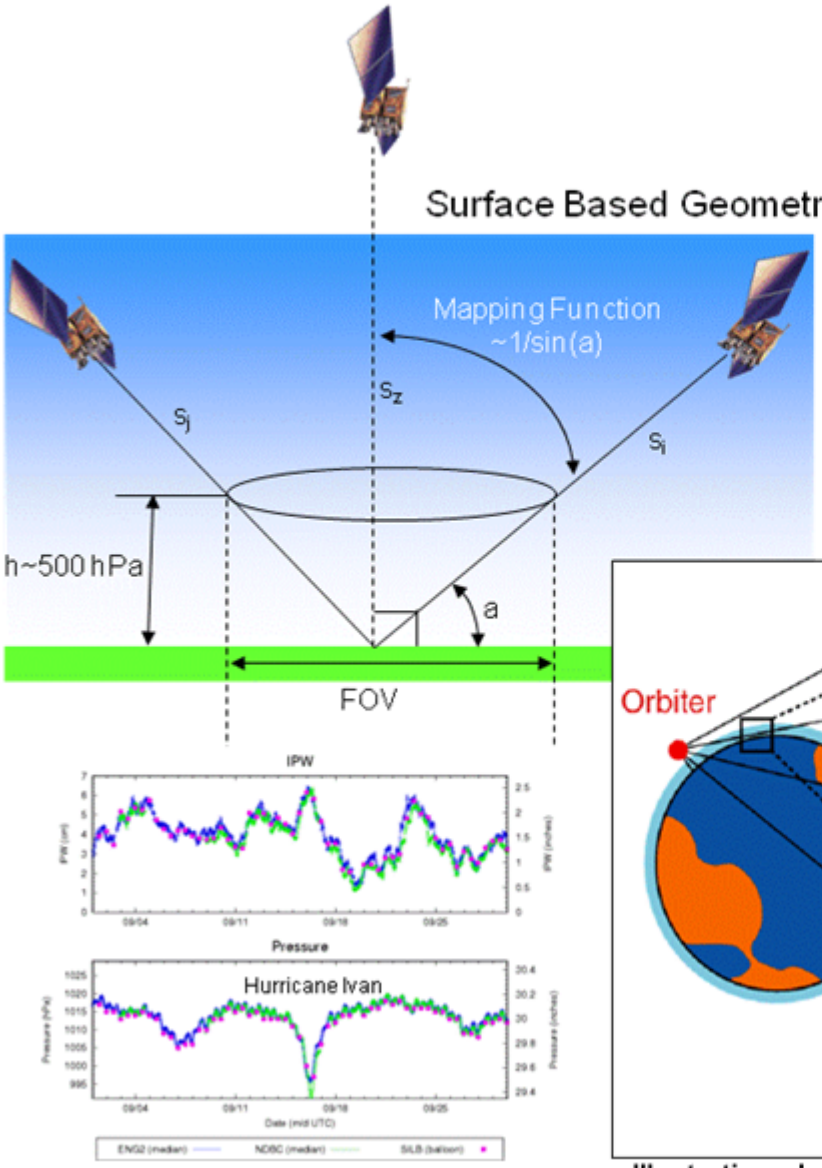
New Applications for GPS

- Ways to assess obs, background, analysis & forecast error characteristics for weather, climate & research applications;
- Investigate other applications aligned with GSD's plans & goals including HWT: GOES Proving Ground;
- New products:
  - high resolution (5 km, 15-min) blended GOES-GPS for AWIPS
  - Other TBD?

Active GPS Met Sites



GPS Met Techniques



In both cases, the fundamental measurement is

$$\Delta s = 10^{-6} \int N(s) ds$$

N(s) the refractivity of the atmosphere along the path of the radio signal $N(s) = 10^6 (n(s)-1)$.

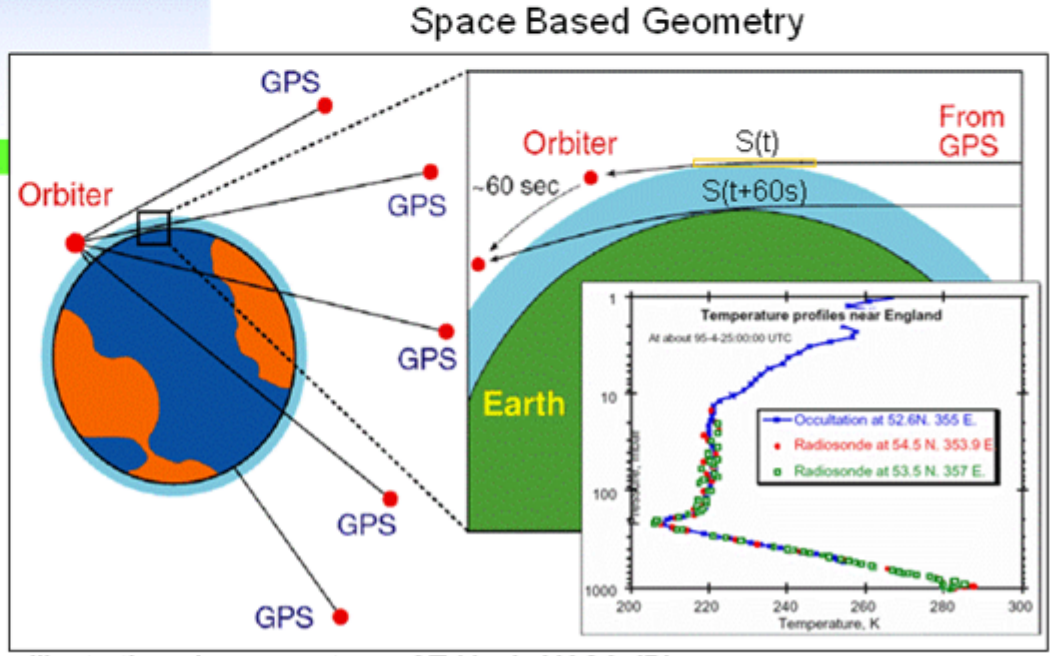
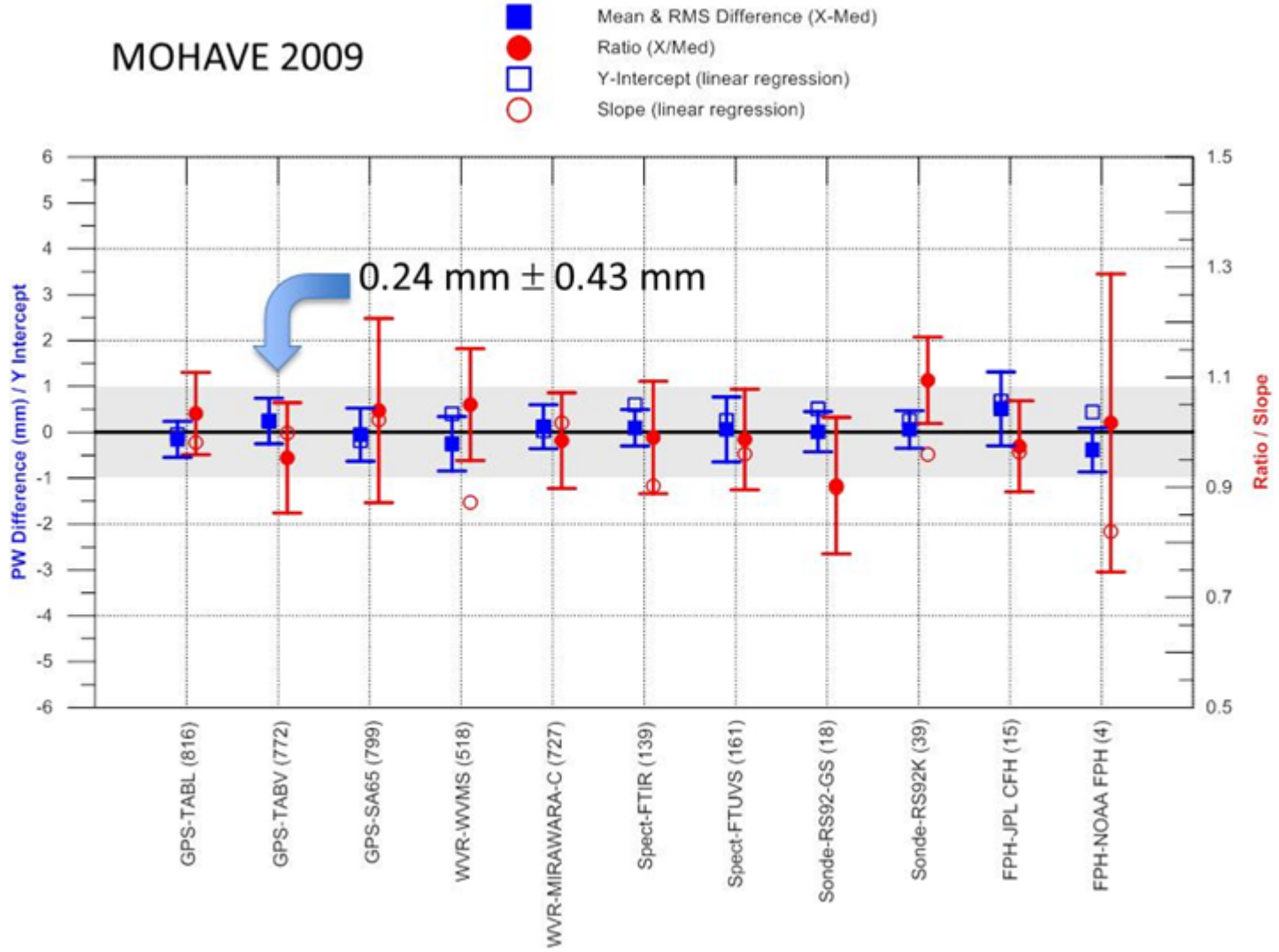


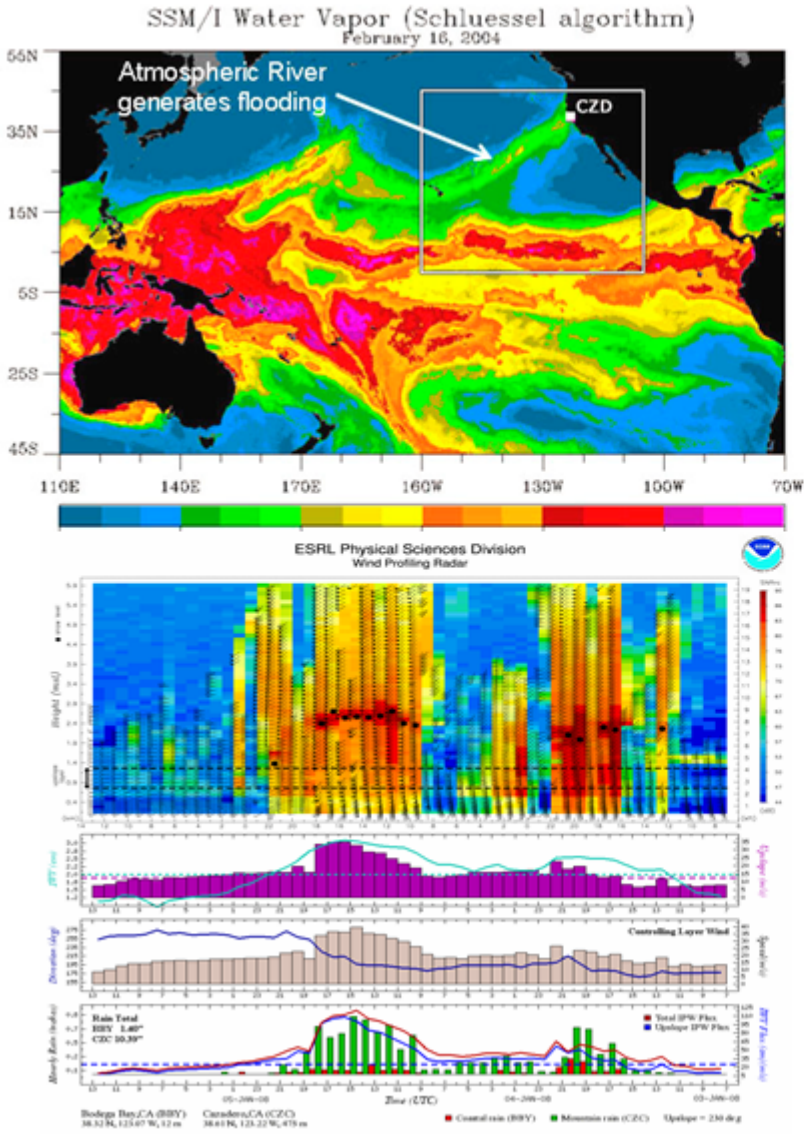
Illustration above courtesy of T. Yunk, NASA JPL.

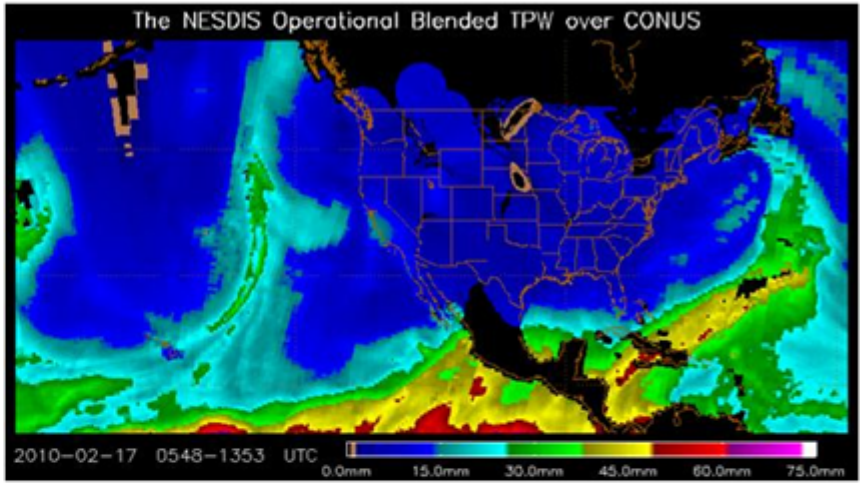
GPS TPW Estimated Uncertainty

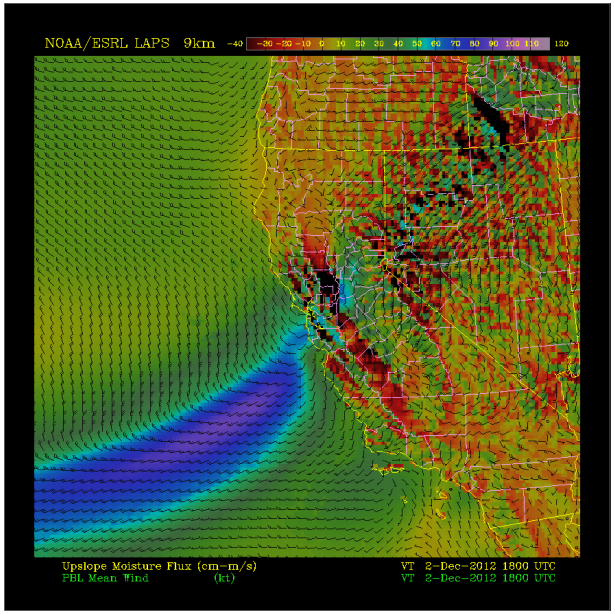


Leblanc et al. 2011: Measurements of Humidity in the Atmosphere and Validation Experiments (MOHAVE)-2009: overview of campaign operations and results, Atmos. Meas. Tech., 4, 2579-2605, doi:10.5194/amt-4-2579-2011.

Significant GPS-Met Contributions

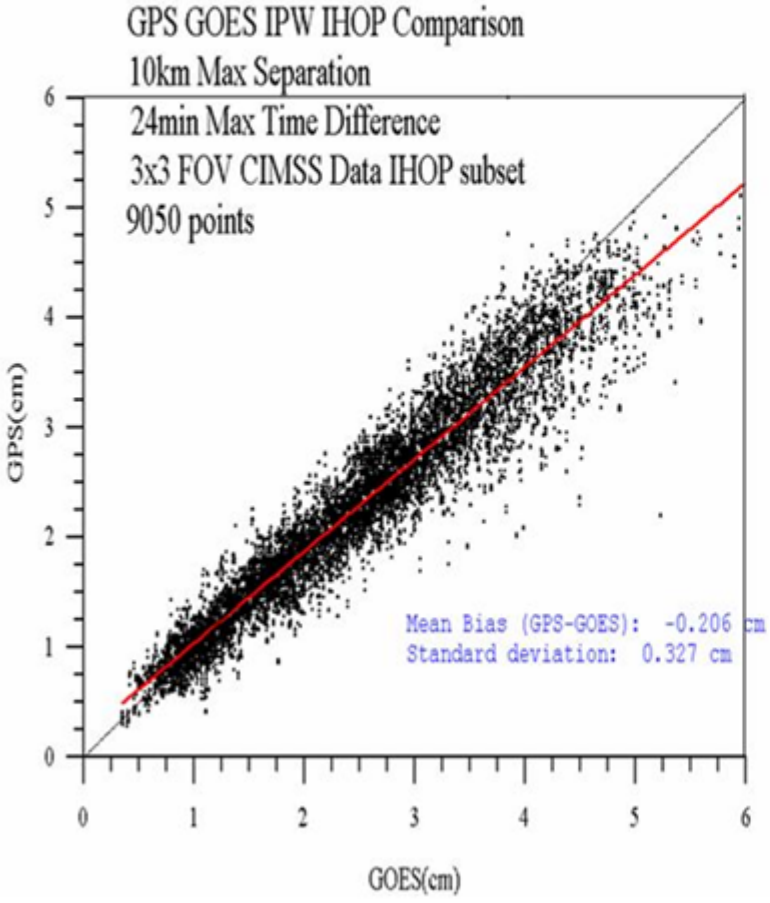


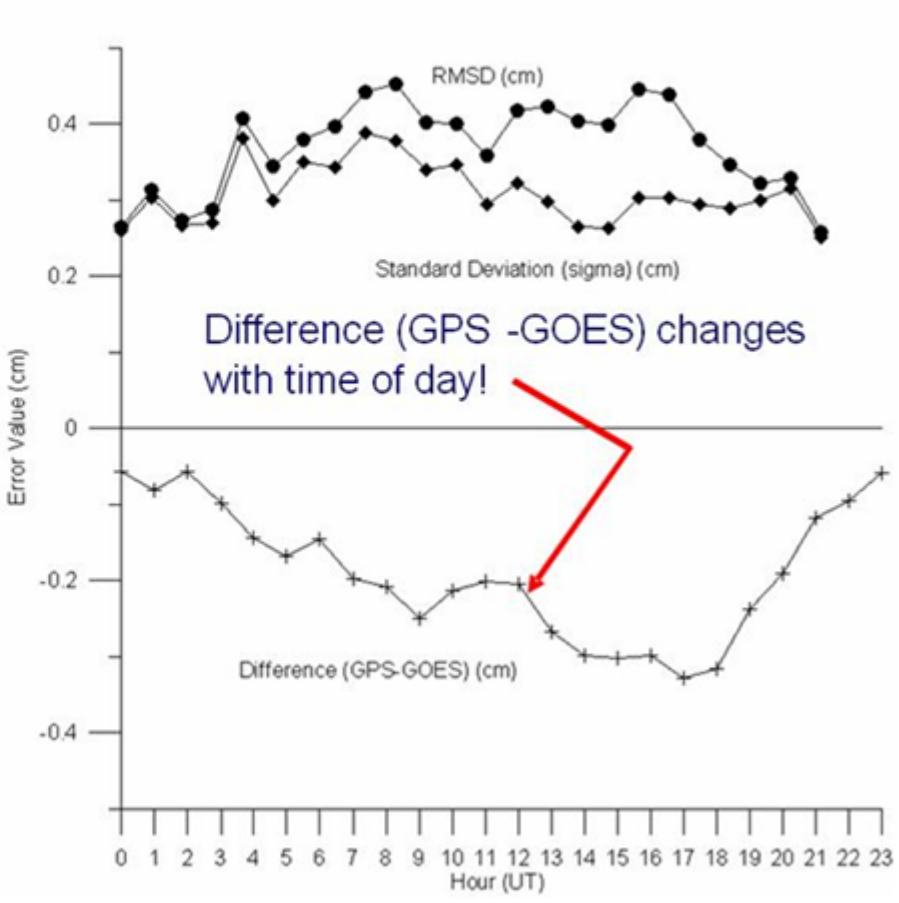




Early Example: Validation of GOES TPW

Systematic differences between operational GOES East TPW products & GPS were detected in 2002.





GPSMET Validation of AIRS Retrievals

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 112, D13S90, doi:10.1029/2005JD006109, 2007

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Radiosonde humidity corrections and potential Atmospheric Infrared Sounder moisture accuracy

Larry M. McMillin,[1] Jiang Zhao,[2] M. K. Rama Varma Raja,[3] Seth I. Gutman,[4] and James G. Yoe[1]

Received 21 April 2005; revised 22 December 2006; accepted 29 December 2006; published 11 July 2007.

[1] Although there are a number of sources of radiosonde data for validation of observations from other atmospheric sensors, routine operational sondes remain the main source for a large volume of data. In this study radiosonde moisture profiles are renormalized using Global Positioning System (GPS) Integrated Precipitable Water (IPW) vapor. The GPS-adjusted radiosonde humidity profiles are then compared to the Atmospheric Infrared Sounder (AIRS) measurements. As a check, AIRS measurements are also compared with unadjusted radiosonde moisture profiles. It is shown that the GPS-adjusted values are in better agreement with the AIRS measurements. On the basis of this result, the GPS-adjusted radiosondes are used to assess the AIRS potential accuracy. This is valid because the errors in the AIRS measurements and the adjustments are independent. The GPS-based renormalization of radiosonde humidity measurements produced a significant improvement in the agreement between AIRS and Vaisala RS 57 H type radiosondes in the lower troposphere, where much of the atmospheric water vapor resides. The adjustment also resulted in improved agreement between AIRS and radiosonde IPW estimates. The results showed a day/night bias in the radiosonde values as compared to the GPS and the AIRS values, demonstrating the potential use of the technique for evaluating and correcting this bias. Established corrections for humidity errors also have been applied to some operational radiosonde observations, specifically the published temperature correction developed for the Vaisala RS80 H type radiosonde. This correction produced a much smaller effect than the GPS adjustment.

Citation: McMillin, L. M., J. Zhao, M. K. Rama Varma Raja, S. I. Gutman, and J. G. Yoe (2007), Radiosonde humidity corrections and potential Atmospheric Infrared Sounder moisture accuracy, *J. Geophys. Res.*, *112*, D13S90, doi:10.1029/2005JD006109.

1. Introduction

[2] The water vapor content of the terrestrial atmosphere plays a significant role in Earth's weather and climate phenomena. Water vapor is a known greenhouse gas and thus important for global warming studies. This central role is a requirements driver for accurate water vapor observations with high temporal and spatial resolution. The main source for atmospheric water vapor measurement data is the radiosonde soundings performed on an operational basis (twice daily at 00 GMT and 12 GMT) at fixed stations around the globe. However, these are limited generally to accessible land regions. Satellite-based water vapor retrievals form a complementary source of data for operational weather/climate prediction or research applications. Satellite-based humidity sensors provide measurements over the vast ocean regions and also over the inaccessible land regions. Several satellite-based water vapor instruments currently provide high-resolution humidity measurements for the Earth's atmosphere. The Atmospheric Infrared Sounder (AIRS) is one such sensor. Satellite-based humidity measurements must be validated and quality checked to permit their use for operational or research purposes. In general the meteorological science community has accepted as reference standard the in situ radiosonde humidity measurements. Therefore the majority of the validation studies of satellite-based humidity retrievals over the years have focused on investigating the comparative characteristics of space based humidity measurements with respect to the corresponding measurements from colocated radiosondes [e.g., see *Kleespies and McMillin*, 1990; *Divakarla et al.*, 2006]. However, some recent studies have identified important problems which adversely impact the accuracy of radiosonde humidity measurements, and also proposed ways to correct these deficiencies [*Jeannet et al.*, 2002; *Wang et al.*, 2002; *Turner et al.*, 2003; *Miloshevich et al.*, 2004]. The problems associated with the radiosonde humidity measurements as shown by these researchers are sensor-type-dependent and therefore have unique characteristics and correction

[1]Center for Satellite Applications and Research, National Environmental Satellite, Data, and Information Service, NOAA, Camp Springs, Maryland, USA.
[2]QSS Group, Inc., Lanham, Maryland, USA.
[3]I. M. Systems Group, Inc., Kensington, Maryland, USA.
[4]GPS-Met Observing Systems Branch, Earth System Research Laboratory, NOAA, Boulder, Colorado, USA.

0148-0227/07/2005JD006109$09.00

Compared AIRS with RAOBS

Larger Differences

Compared GPS with RAOBS

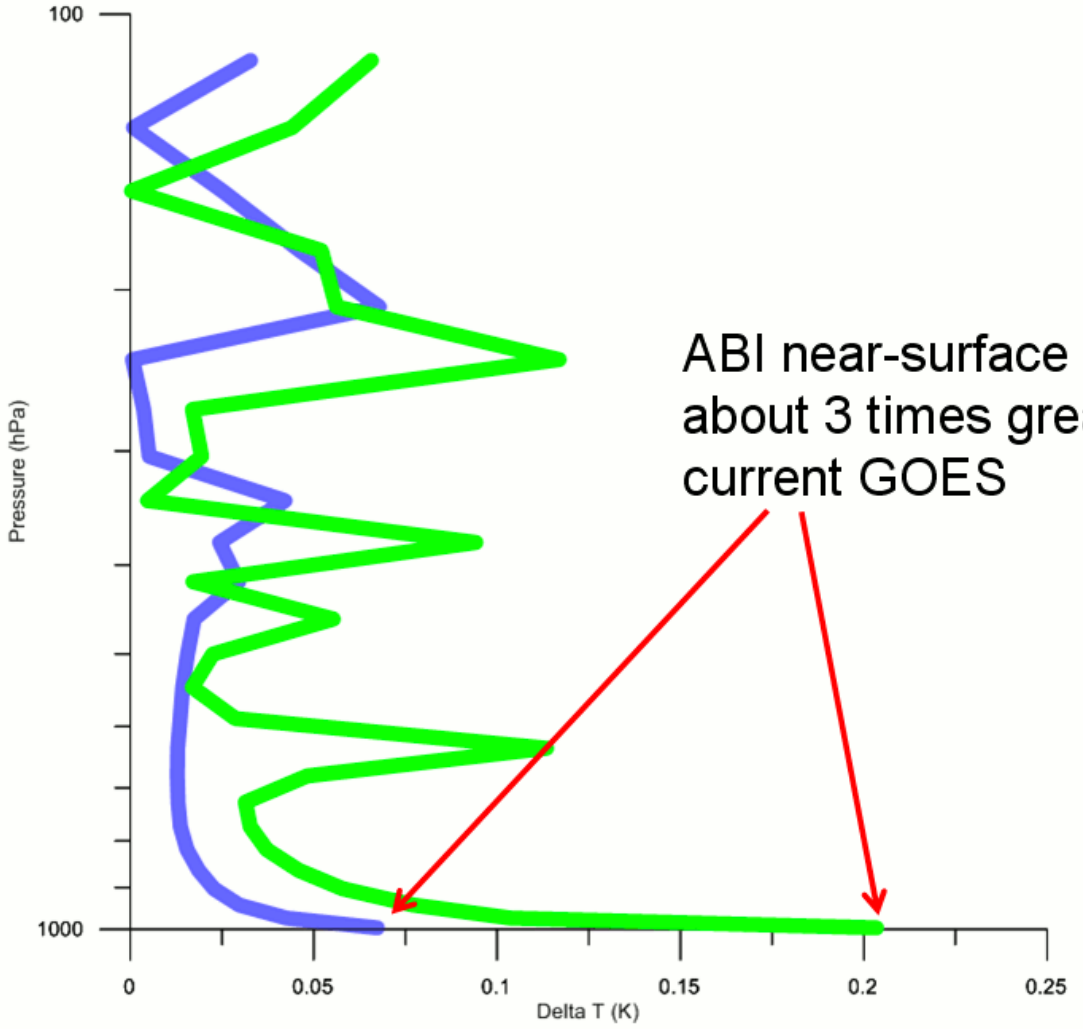
Adjusted RAOBS to give best fit to GPS

Compared Adjusted RAOBS to AIRS

Smaller Differences

Thermal Sensitivity to 1% Moisture Profile Uncertainty

GOES blue ABI green



ABI near-surface uncertainty about 3 times greater than current GOES

FAB Observing System Plans

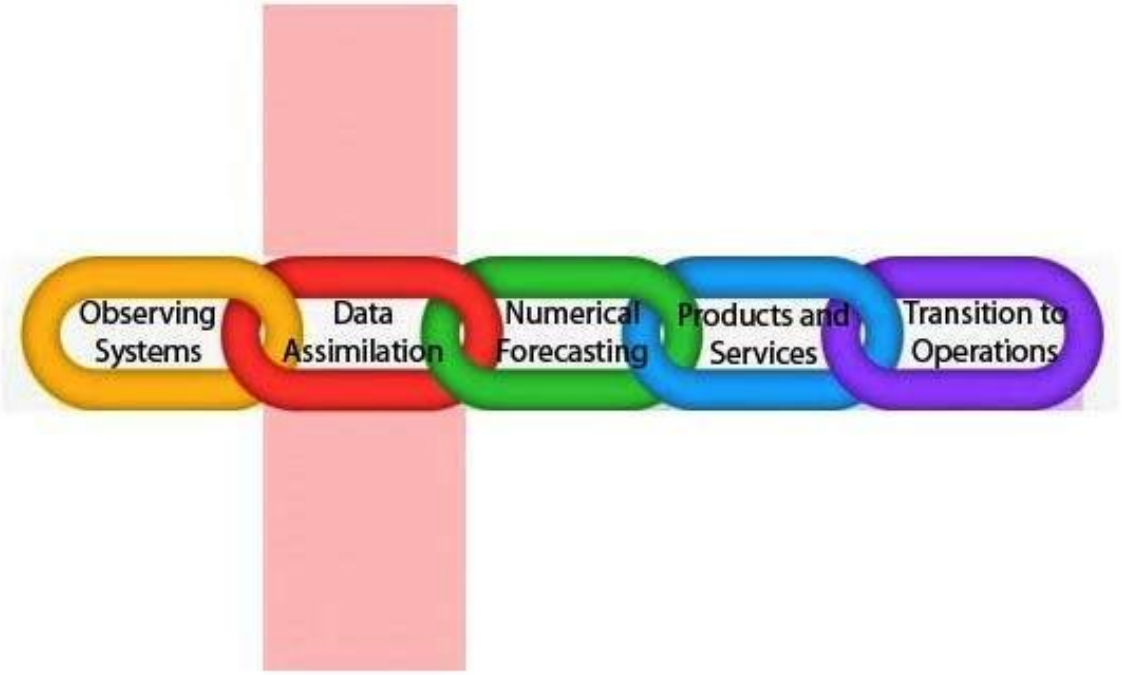
- Data Assimilation
- Develop ZTD modules for V-LAPS & GSI to expand the number of domestic & international PW observations.

- Ensemble Forecasting & NWP
  - Study the impact of data denial on individual ensemble members;

- New Products & Services
  - Continued emphasis on satellite Cal/Val
  - Higher-rate PW, UMF and IVT and other NOAA testbeds
  - Provide as-required moisture observations in other regions including SoCAL and HMT-SE.
  - Develop updated PW climatology for CONUS

- Techniques to improve verification of point & area forecasts.

Local Analysis and Prediction System (LAPS)



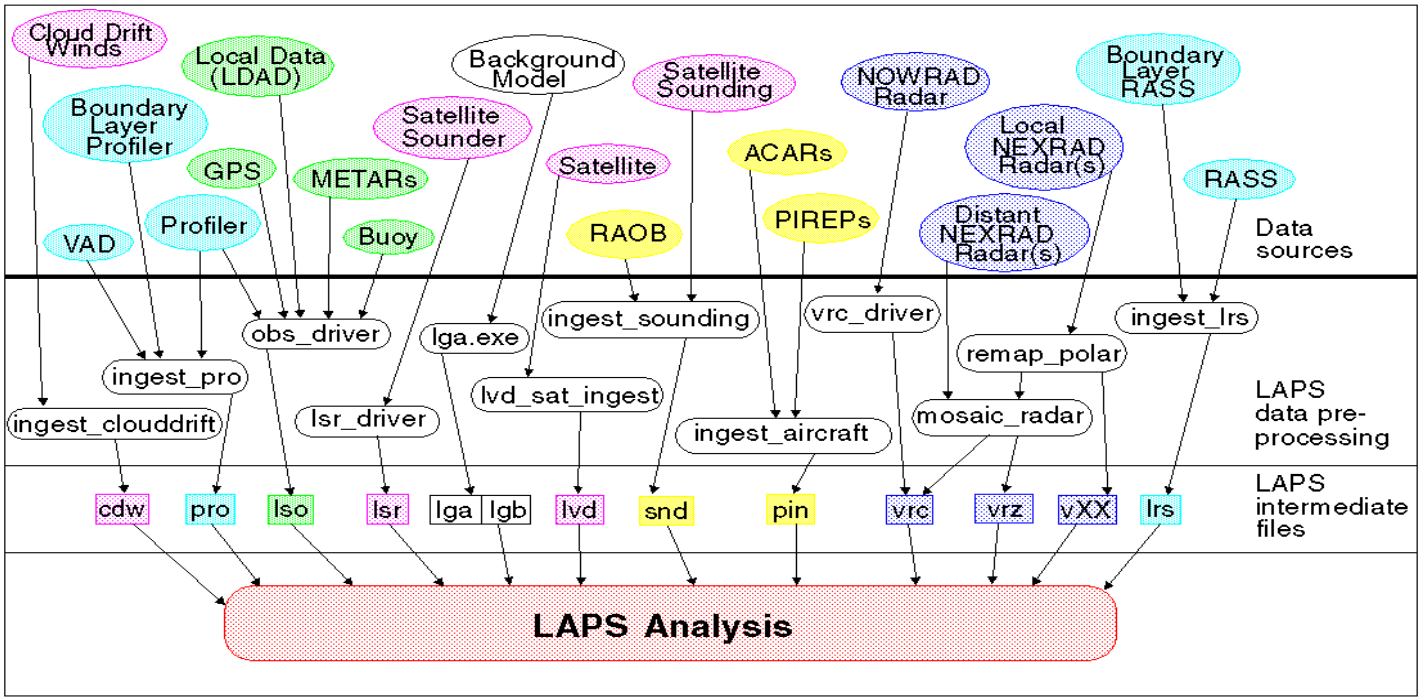
(Variational) LAPS Motivation

High Resolution (500m – 20km), rapid update (10-60min)

Highly portable system – about 150 users world wide

- Federal Gov't – NWS, RSA, PADS, FAA, DHS
- State Gov't – California Dept of Water Resources
- International – Finnish Met. Inst., China Heavy Rain Inst.
- Global analysis – used by SOS

Wide variety of data sources:

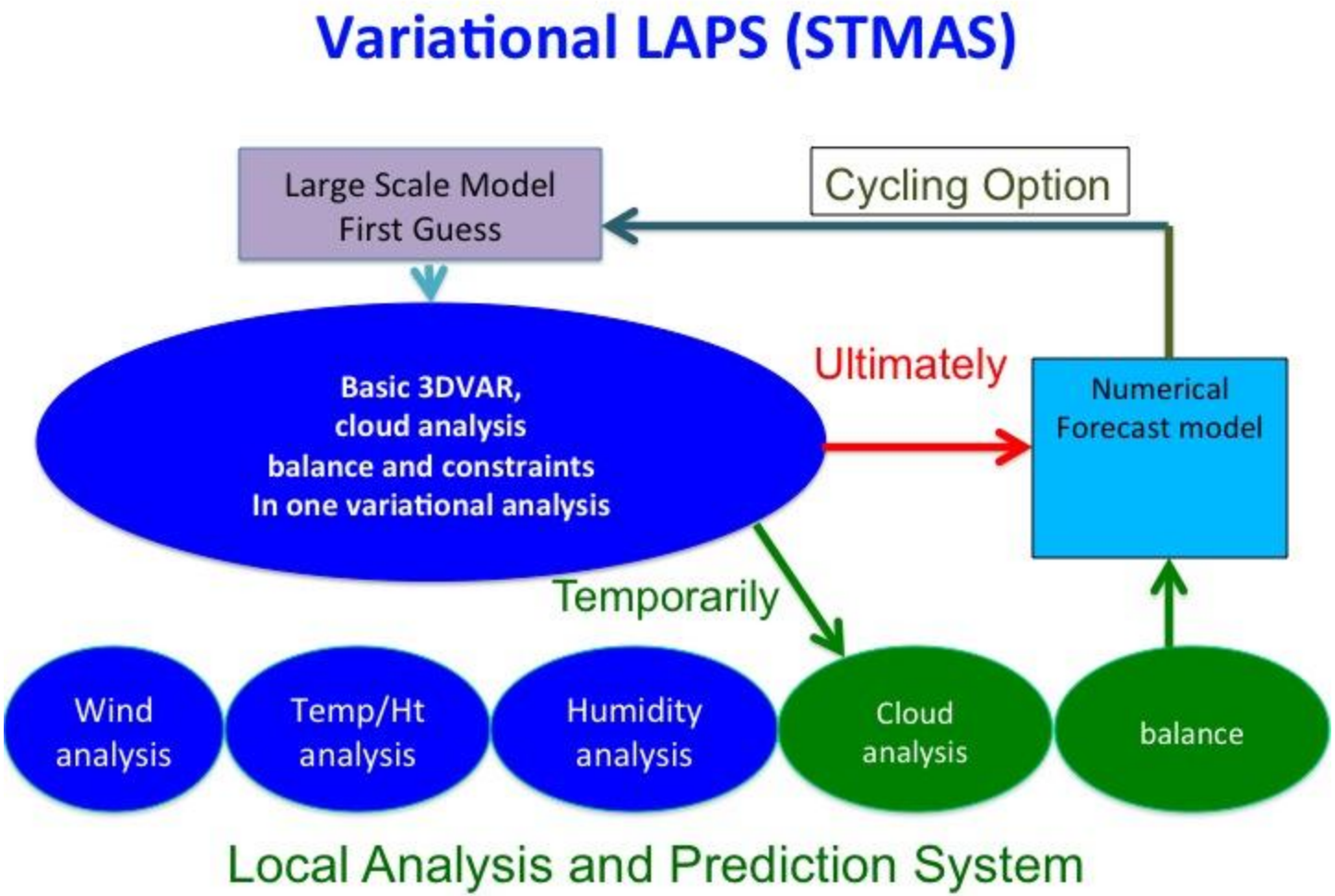


LAPS Features: toward fully variational

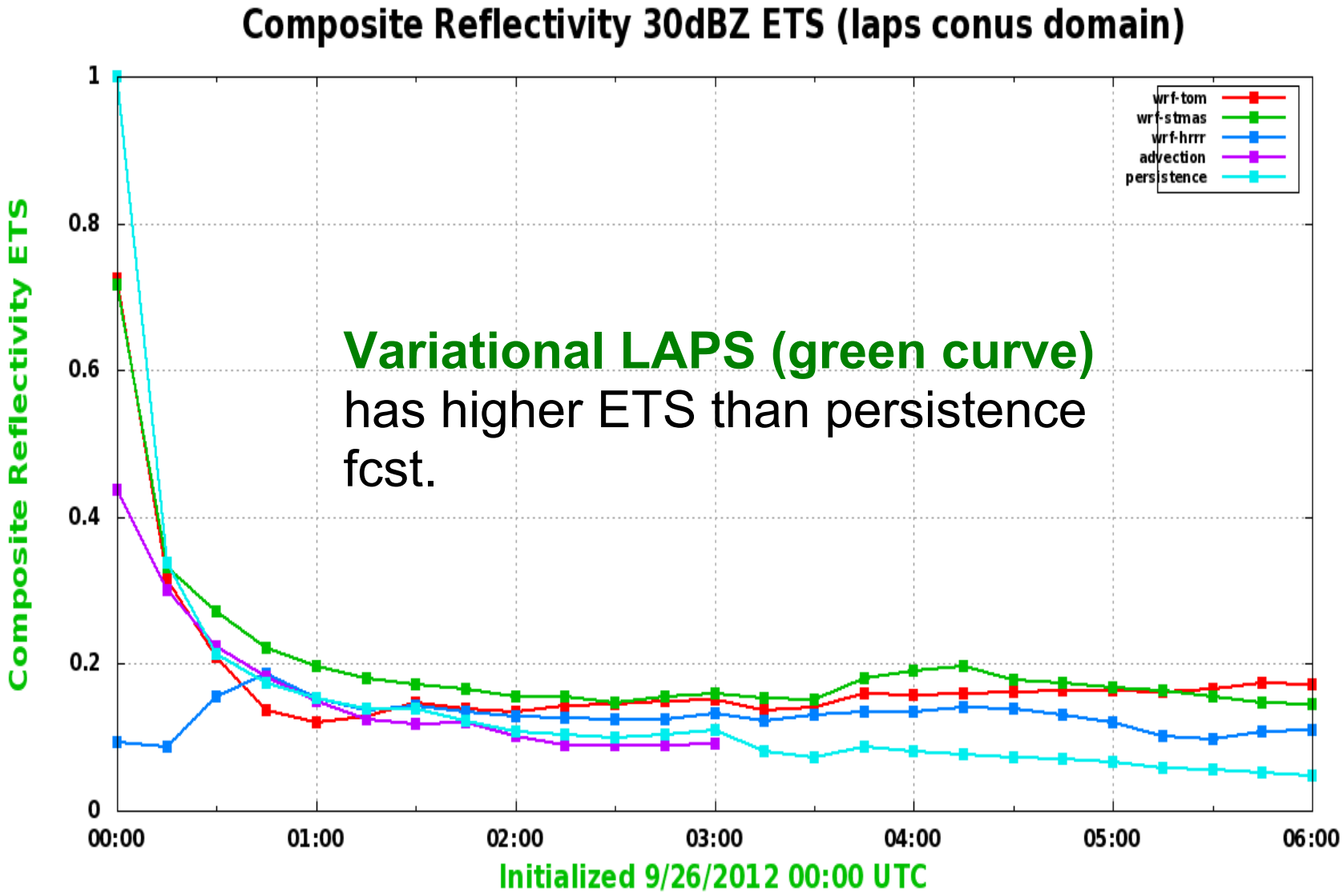
- Variational LAPS combines advantages from traditional LAPS and modern data assimilation techniques and reduces their limitations;
- It applies all state of art DA and numerical techniques (such as multigrid, which is unique in the DA community) to build a next generation NOAA data assimilation system;
- Modernization of traditional analysis to fully variational analysis (var-LAPS = STMAS) by **a multigrid technique**;
- Hot-start with cloud, vertical velocity and other meteorological states reflecting latent heat and forcing;
- Multiscale analysis;
- Efficient analysis for frequent analysis cycles (currently running on a *single processor* with *15 minute cycle* for CONUS domain).

Xie et. al. 2011 MWR on STMAS (variational LAPS)*;*
Briggs 1987 SIAM tutorial on multigrid.

Current variational LAPS status

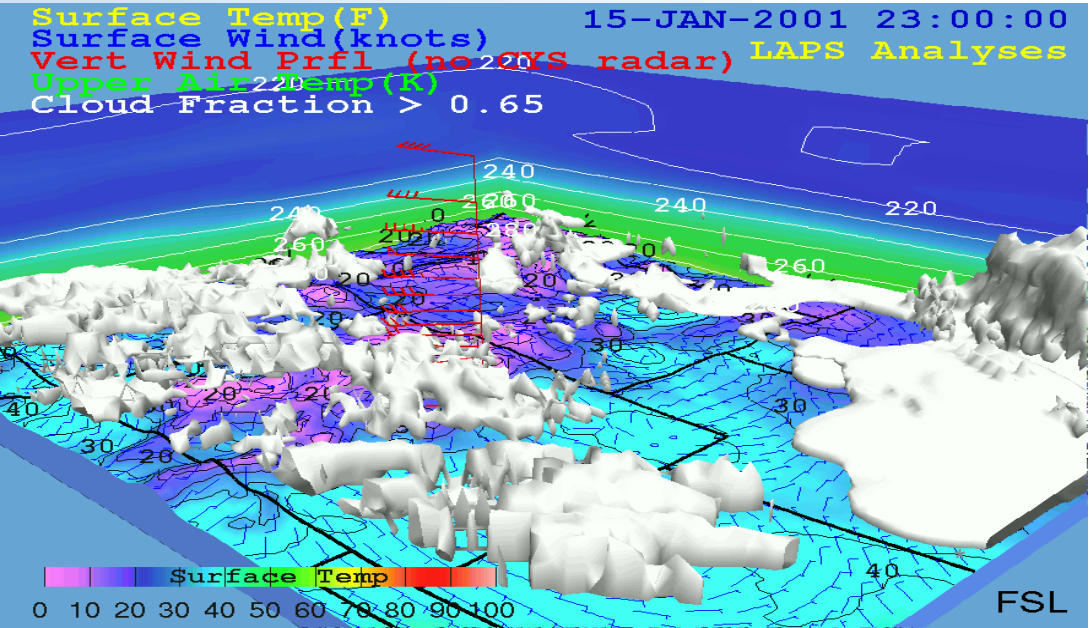


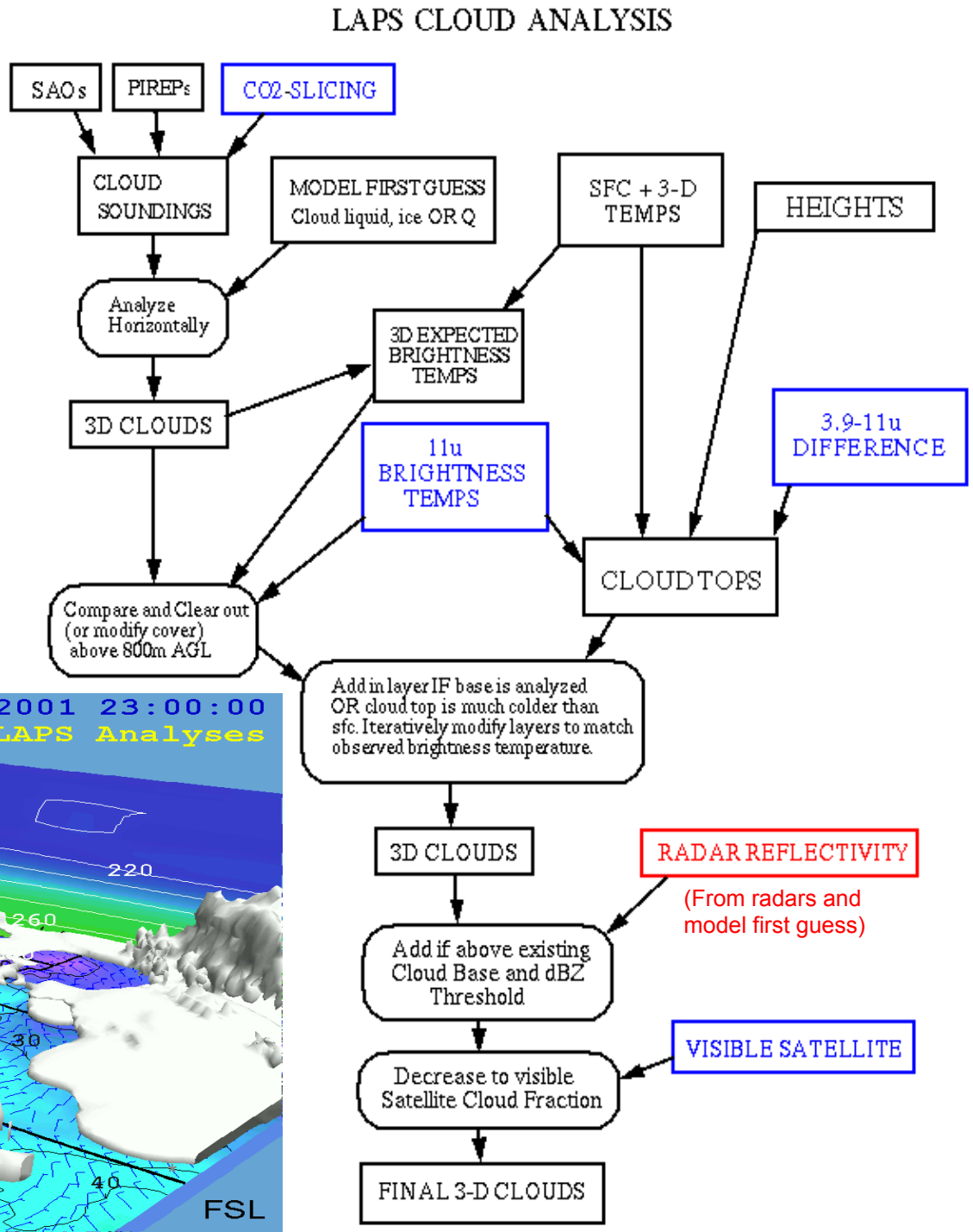
LAPS forecast verification



Cloud Analysis Flow Chart

Cloud Fraction 3-D Isosurface



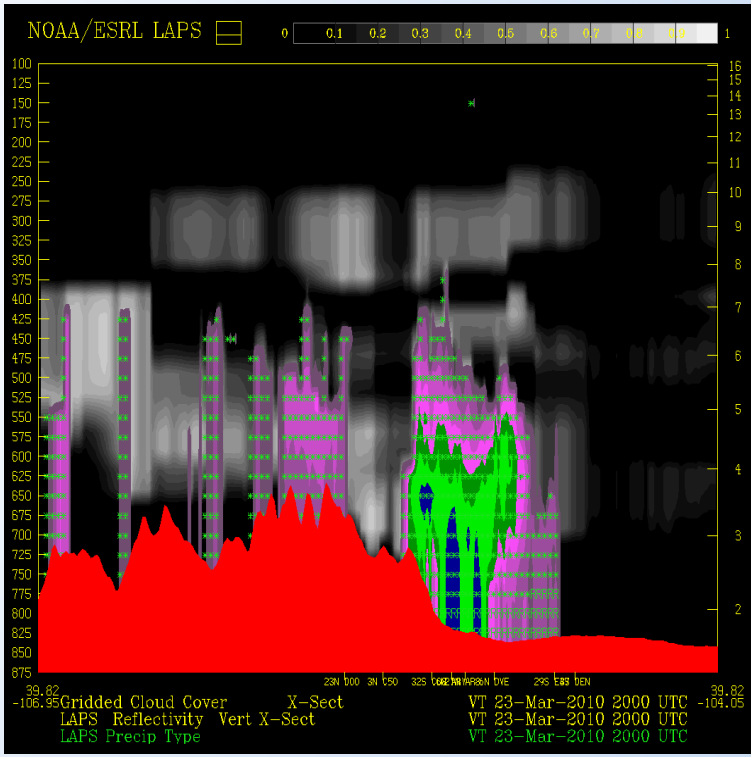


Global Horizontal Irradiance (GHI) Analysis

- Derived from 3-D cloud fraction analysis and simple clear-sky solar radiation calculation
  - High Resolution (e.g. 1km)
  - Rapid Update (e.g. 15min)
  - Compares well with independent observations

Hot-start with cloud/rain/snow

- GHI = I_o t a f
  - I_o = Top of Atmosphere Normal Incident Radiation
  - T = Overall Transmittance (0.73)
  - a = 0.9 * sin(altitude) + 0.1 * $\sin^2$(altitude)
  - f = cloud fraction term

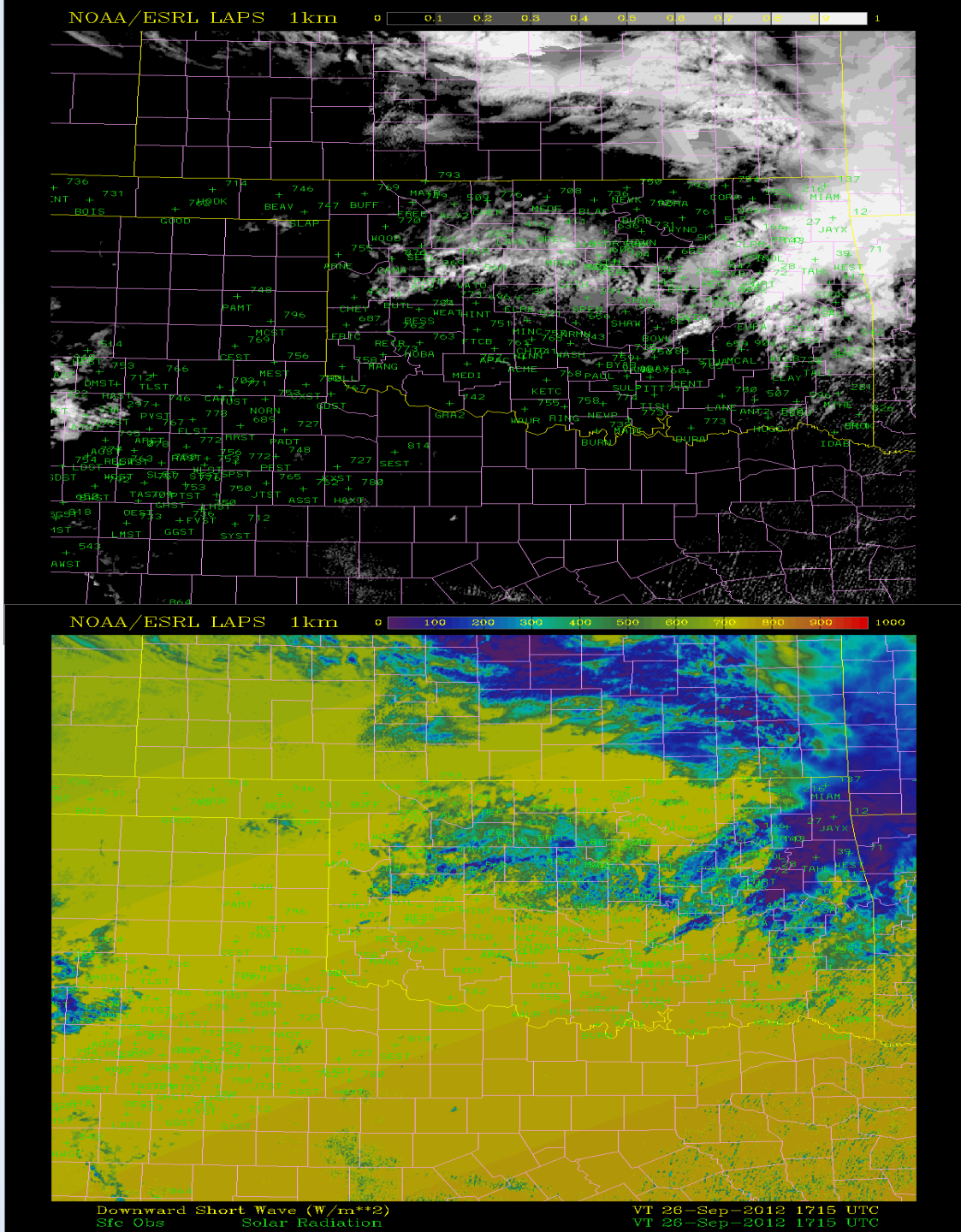


LAPS 1-km Cloud Fraction Analysis with Independent GHI Obs. Overlay

3-Frames at 15-minute interval

Global Horizontal Irradiance Analysis + Observations

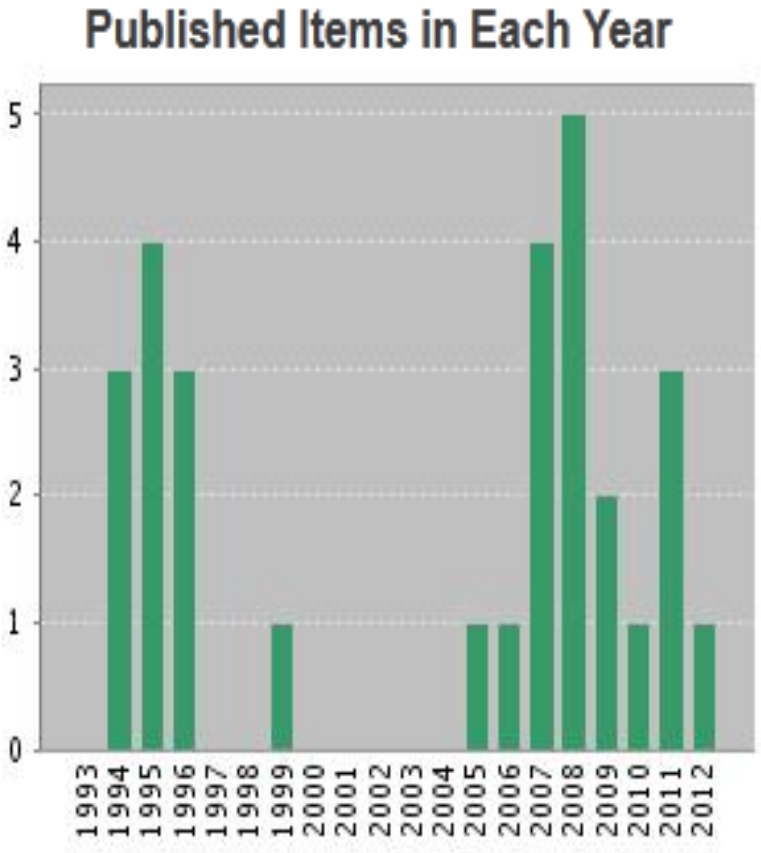
Utilizes GOES imagery and 3-D cloud analysis allowing rapid 1km resolution update

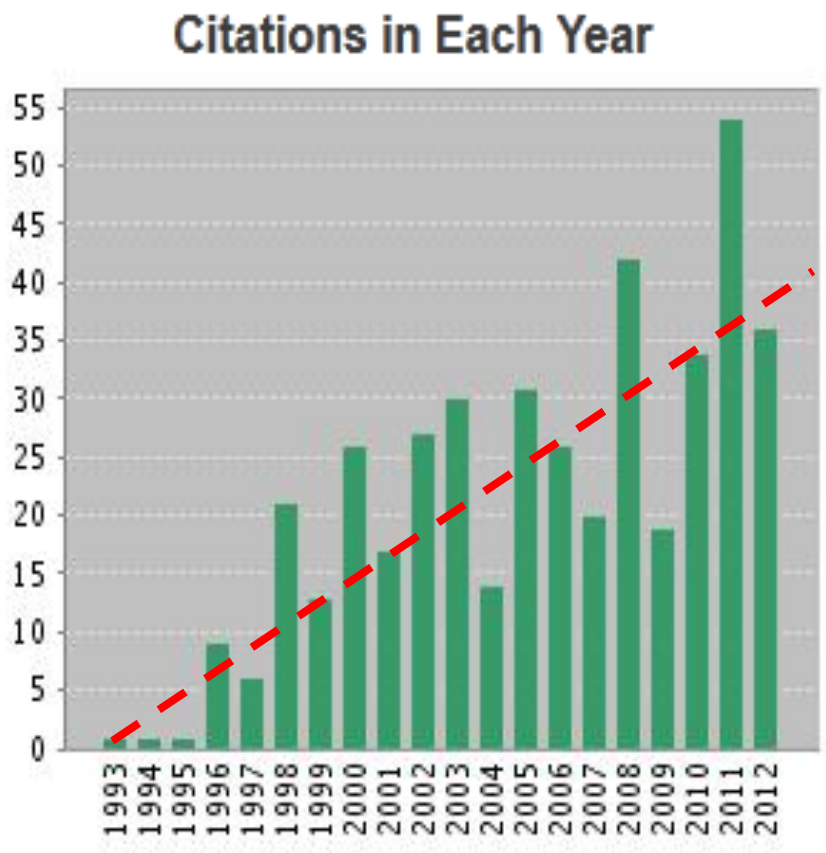


LAPS USER BASE

- NOAA
  - ~120 WFOs (via AWIPS), ARL, NESDIS
- Other US Agencies
  - DHS, DoD, FAA, CA DWR, GA Air Qual.
- Academia
  - Univ of HI, Athens, Arizona, CIRA, UND, McGill
- Private Sector
  - Weather Decision Tech., Hydro Meteo,
  - Precision Wind, Vaisala, Telvent
- International agencies (10+ countries)
  - KMA, CMA, CWB, Finland (FMI), Italy, Spain,
  - BoM (Australia), Canary Islands, HKO,
  - Greece, Serbia, Nanjing Inst. of Met.

LAPS SCIENTIFIC IMPACT – REFEREED PAPERS





- **30 refereed publications**
  - 1-2 refereed papers per year
  - Total 432 publications

- **Total 4163 citations** in refereed papers
  - *~ 40 / year recently*

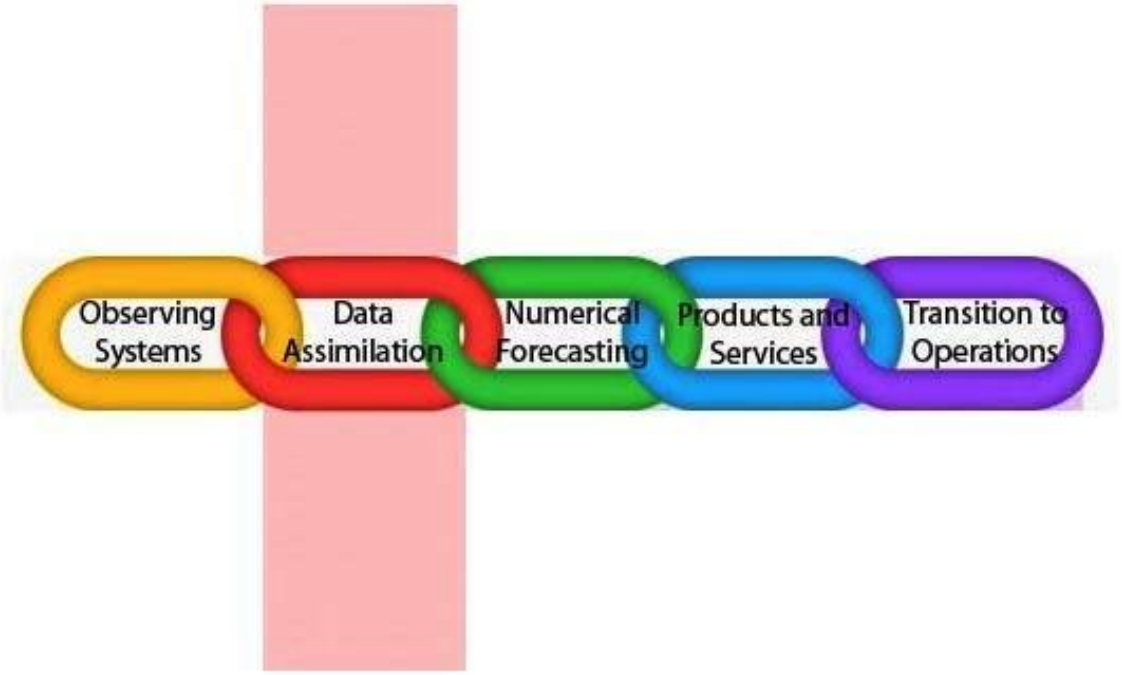
Some LAPS projects/applications

- Situational awareness / Nowcasting
  - –NWS WFOs
- Warn-On-Forecasting (WOF)
  - –HWT
- Aviation weather – Convective Initiation
  - –“STMAS is a key component of the 0-2 hr forecast” – MIT/LL
  - –Terminal-scale forecasting (ITWS)
- Hydro-meteorological Forecasting
  - –Heavy precipitation – HMT
- Decision support for weather dependent operations
  - –AFTAC, RSA
- Fire Weather
  - –Downscaling wind and other variables
- Renewable Energy
  - –Boundary layer winds & solar radiation
- Dispersion modeling
  - –GTAS (DHS)
- Tropical cyclone forecasting
  - –Taiwan Central Weather Bureau

Future

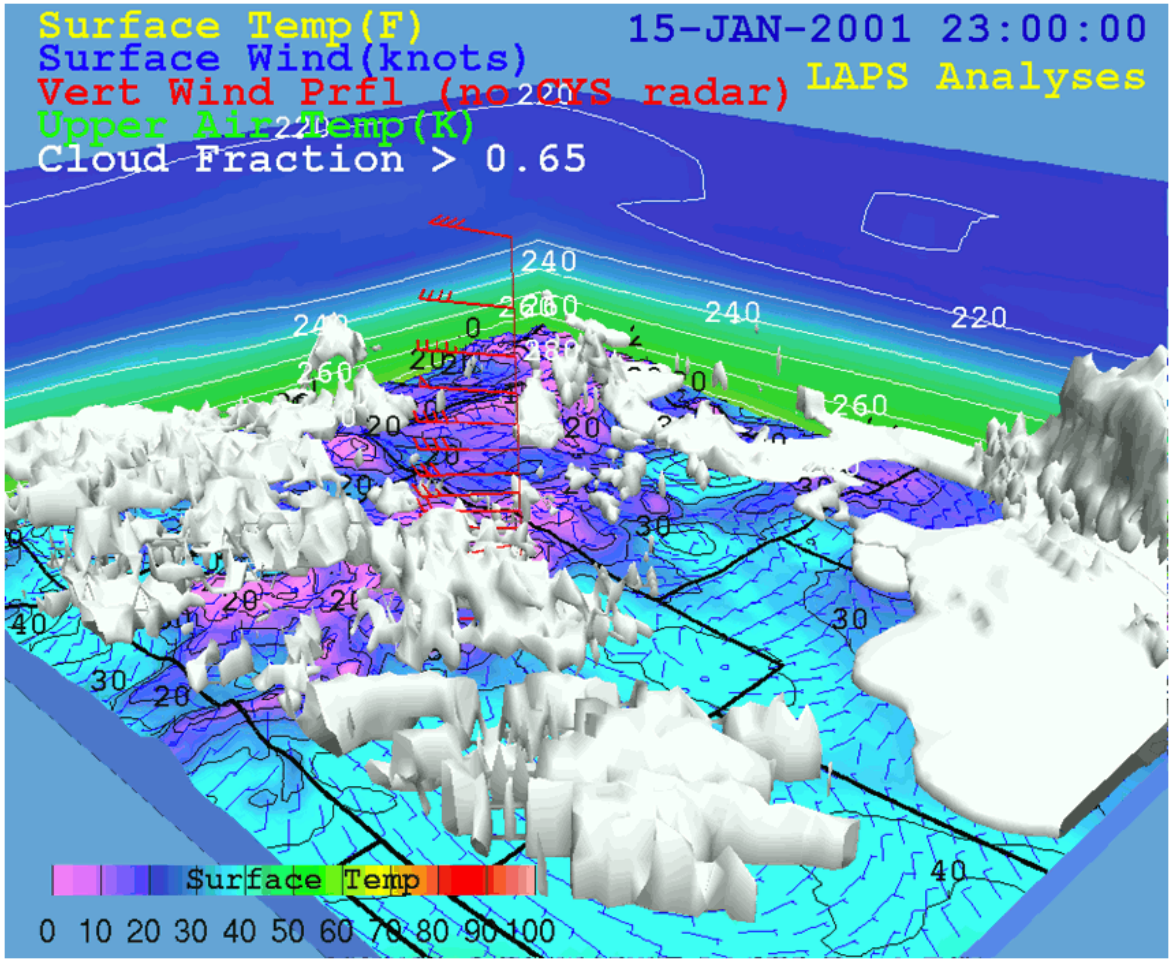
- Developing better balanced or constrained in the new terrain-following;
- Developing a fully variational cloud analysis;
- Integrating its multiscale, hot-start, and variational cloud analysis into a fully variational analysis;
- Incorporating sophisticated ensemble covariance into the variational analysis in an improved scheme;
- Developing a global data assimilation scheme for FIM/NIM;
- Improving efficiency and portability for forecasters in WFO and around the world for supporting various applications;
- Parallelizing the current analysis software;
- Developing a fully 4-dimensional variational analysis.

LAPS Users Workshop



2ND LAPS USER WORKSHOP

Global Systems Division
NOAA/OAR/ESRL



Sponsors:
Forecast Applications Branch
NWS OCWWS

23-25 October 2012, Boulder, CO

2ND LAPS User Workshop Attendees

Oct. 23-25 2012, ESRL, Boulder, CO

WORKSHOP LOGISTICS

- **Co-organized by OCWWS/NWS & Forecast Applications Branch**
- **Conducted 23-25 Oct 2012 at ESRL in DSRC, Boulder, Colorado**

- **77 participants, including 23 remote**
  - **NOAA 31** GSD; NWS OCWWS, OST, Regions, NWS Training Center
  - **International 17** China, Finland, Greece, Italy, Korea, Serbia
  - **Academia 15** NCAR, Universities
  - **Private Sector 9** AlphaTRAC, Radiometrics, Telvent, Toyota Racing, Vaisala, WDT
  - **Other agencies 5** DOD, NASA

- **38 presentations, including 5 posters**

- **2 sessions of Working Group discussions (Three topical areas)**
  - **Scientific opportunities for further development**
    - Fully variational multiscale DA approach
    - Dynamical constraints consistent with WRF
  - **Use of LAPS**
    - User feedback
    - Change control management
      - Test & evaluation
      - Role of NWS
  - **Collaboration / data / software**
    - Shared algorithm / software development
    - Software to digest new types of data
    - LAPS repository

Highlights

- Attendance more than doubled compared to 1st meeting
  - Broad spectrum of users & developers
- Continued strong interest in unique features of LAPS
  - Quality, portability, speed, & ease of use
- LAPS used operationally by more than 20 agencies
  - Federal, state, private, academia, international
- Variational version of LAPS introduced
  - Competitive with nowcasting methods
- Community development effort
  - Contributions from multiple national / international groups
- Major scientific impact
  - ~400 citations to 30 refereed NOAA LAPS publications
  - 4,000+ citations to 400+ total NOAA LAPS publications

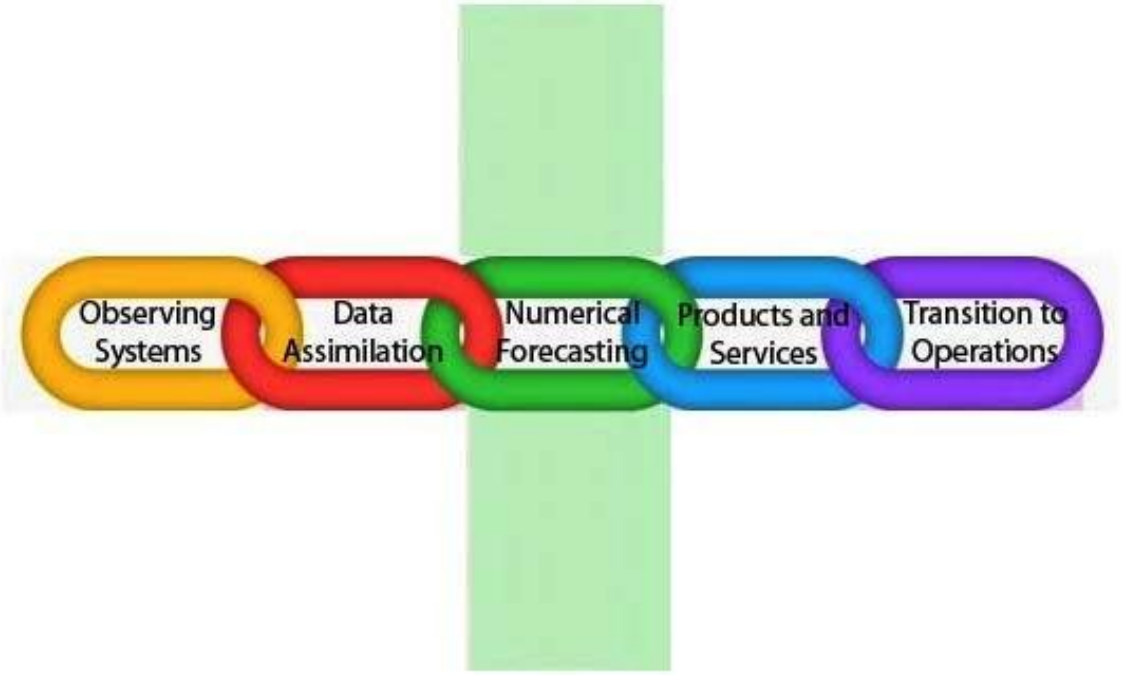
Major Recommendations

- Accelerate development & implementation of
  - Variational cloud analysis, dynamical balance, & terrain following coordinate system
- Enhance community development efforts via
  - Make code repository more accessible to user community
  - Recommended "rules of engagement"
- Develop wizards for installation, data ingest, & verification
  - In AWIPS2 environment - Make AWIPS2 available to community
- Make the use of new local observations easier
  - Build globally comprehensive data ingest capabilities

Major Recommendations - 2

- Form LAPS User Group (LUG)
  - Shares good practices, advocates
- Define Change Control Management
  - Formal evaluations with LUG
- Internationally coordinated development of LAPS
  - Coordinated planning, visitor exchange, etc
- Next workshop in 2014
  - Regional workshops in Asia & Europe in 2013?

Numerical Forecasting



Recent Modeling Efforts

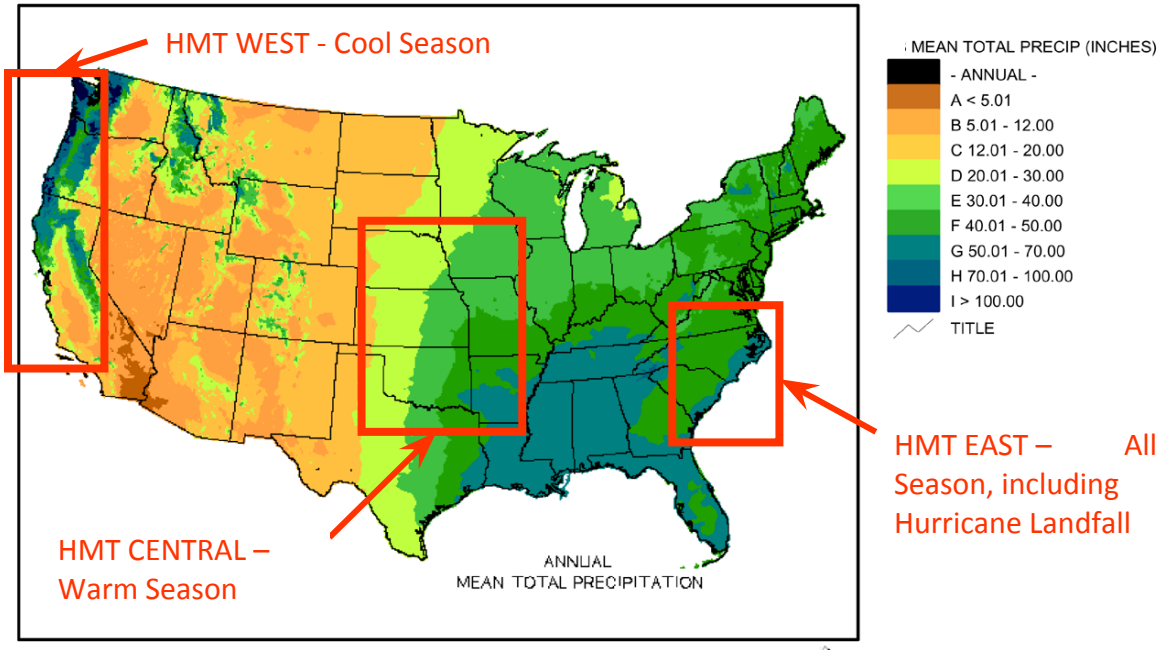
1. Hydrometeorology Testbed (HMT)
   a. Details at http://www.esrl.noaa.gov/psd/programs/hmt/2010/
2. Hazardous Weather Testbed (HWT)
   a. Details at http://laps.noaa.gov/hwt/hwt.html
3. Windsor Tornado Study
   a. Details at http://laps.noaa.gov/windsor/windsor.html
4. Solar Radiation Analysis & Forecasting
   a. Details at http://laps.noaa.gov/solar/

NWP 1: Hydrometeorology Testbed (HMT)

Overview

- **Goal is to improve forecasts of rain and snow and associated hydrology**
- **Uses local-state-federal, and private-public-academic partnerships**

Benefits: Accelerates improvements in QPF and flood forecasting, with impacts on transportation, ecosystems, emergency management, flood control and water supply. Science and field tests will advise on how best to fill gaps in observational and modeling systems.

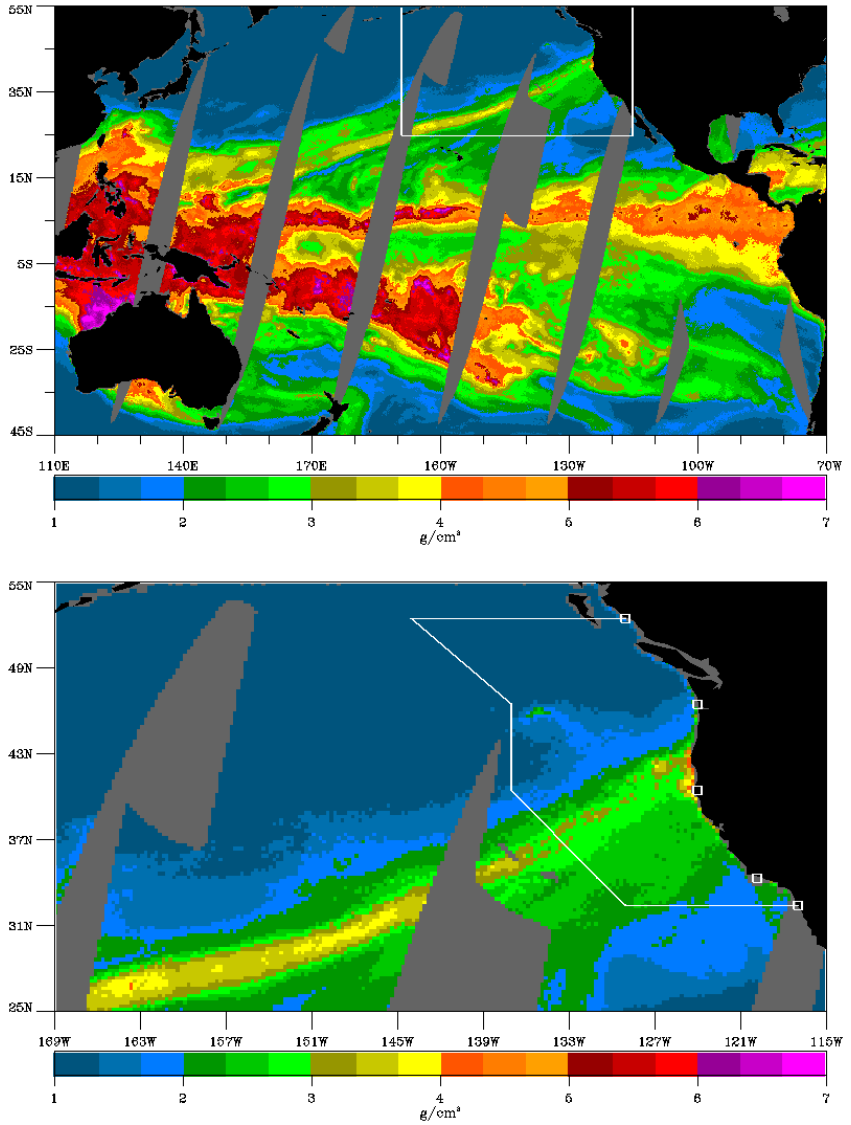


ATMOSPHERIC RIVERS

○ During the winter season significant precipitation events in California are often caused by land-falling “atmospheric rivers” associated with extra tropical cyclones in the Pacific.

○ Atmospheric rivers are elongated regions of high values of vertically integrated water vapor over the Pacific and Atlantic oceans that extend from the tropics and subtropics into the extratropics and are readily identifiable using SSM/I.

○ Due to the terrain steepness and soil characteristics in the area, a high risk of flooding and landslides is often associated with these events.

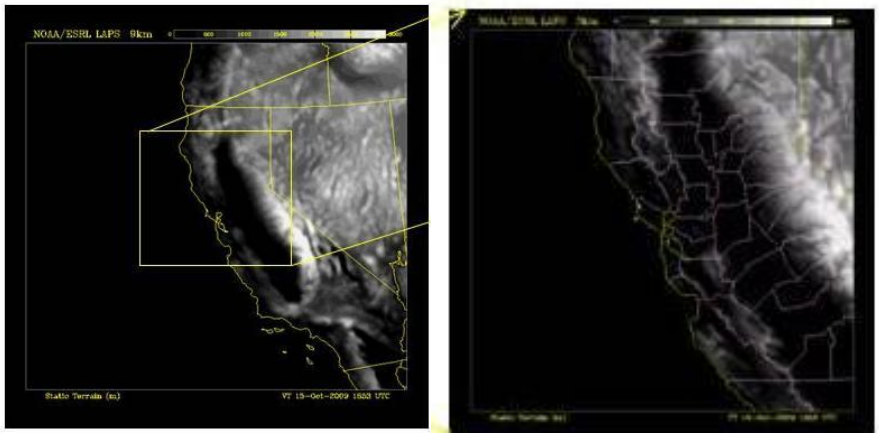


Role of ESRL/GSD/FAB in HMT NWP

- **Goal is to improve forecasts of rain and snow and associated hydrology**

ESRL/GSD/FAB group roles:

- Design of the limited-area ensemble
- Provide real time ensemble precipitation forecasts
- Provide numerical model support for PSD moisture flux tool
- Collaborate with PSD colleagues in addressing various scientific questions

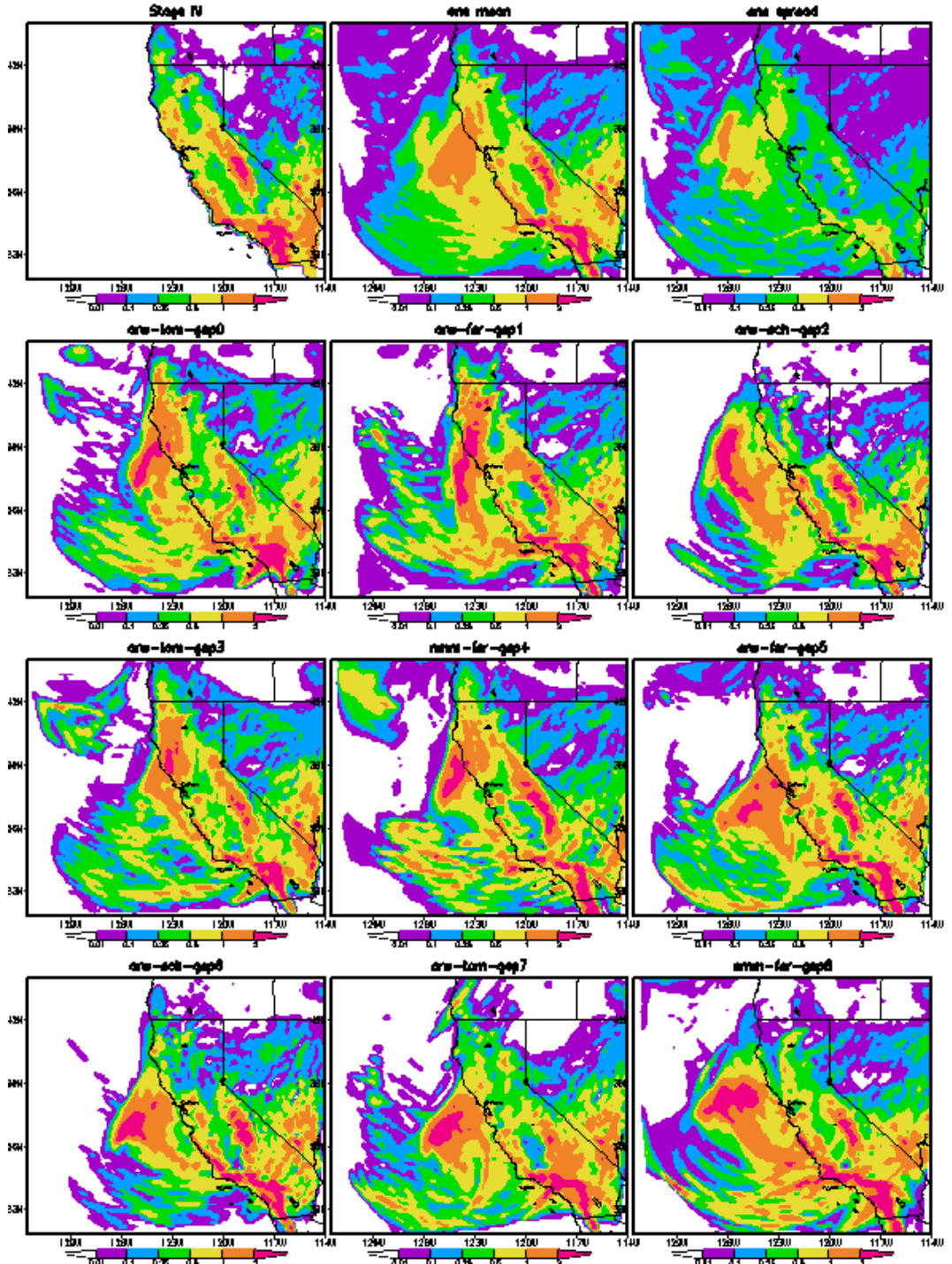


- Winters 09-10, 10-11, 11-12
- Domains: 9- and 3-km
- Nine members with diversity of
  - models
  - physics
  - initial and boundary conditions
- Realtime and retrospective (ARRFEX)

QPF

Example of 24-h QPF
9-km resolution

9 members:
ARW-TOM-GFS
ARW-FER-GEP1
ARW-SCH-GEP2
ARW-TOM-GEP3
NMM-FER-GEP4
ARW-FER-GEP5
ARW-SCH-GEP6
ARW-TOM-GEP7
NMM-FER-GEP8

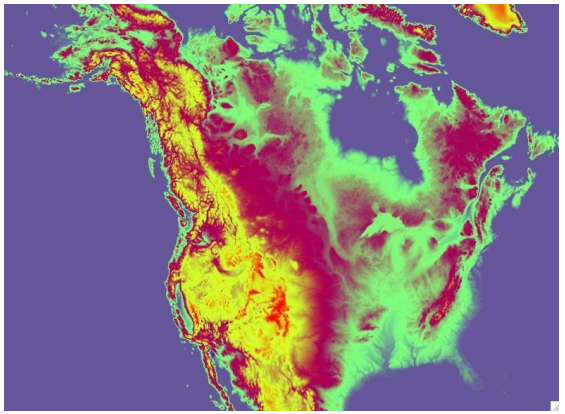


Feedback from ARRFEX forecasters about the GSD/FAB HMT ensemble

- "…the HMT…was by far the most superior of the guidance we interrogated during this experiment with high-resolution data over the favored topography."
- "…HMT ensemble members clustered well, and the maxima were all false alarms."
- "In particular, the HMT and Reforecast information was very helpful (...)"
- "The HMT ensemble was about the best in accurately predicting the magnitude and placement of heavy precipitation. The only drawback of this product…is that its domain is too small."

For 2012-2013 season

- Ensemble expanded to 9-km North American domain (just started to run realtime)
- Three-km nested run
- Results sent to PSD, HPC, and CA WFOs
- Collaboration with Developmental Testbed Center (DTC) to test aspects of the GSD/FAB HMT ensemble in NCEP operational SREF

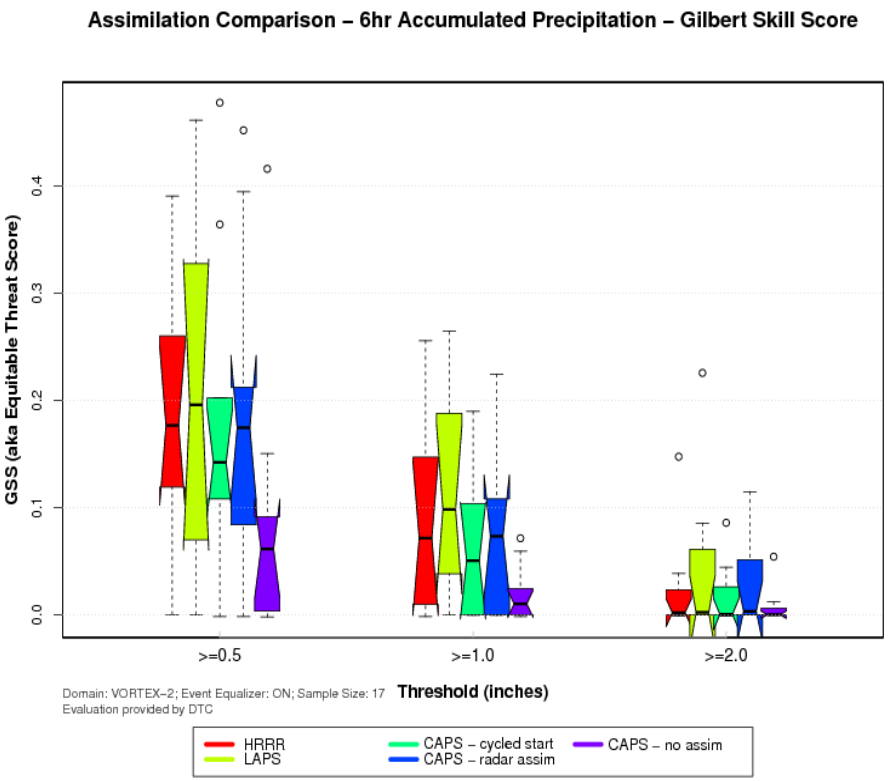


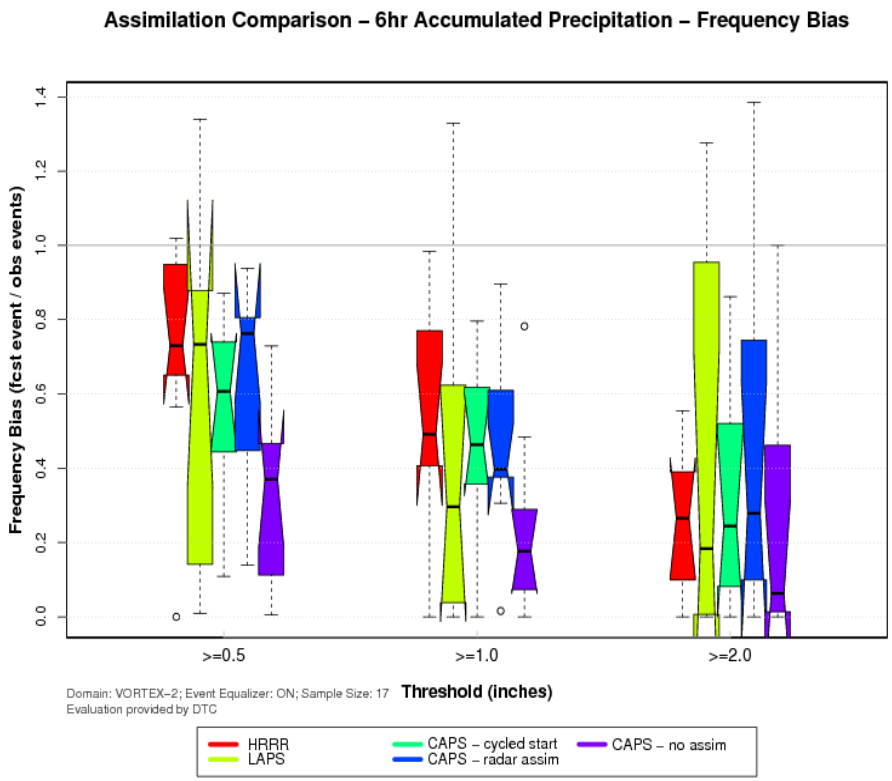
NWP 2: Hazardous Weather Testbed (HWT)

Overview

- 2011 experiment: FAB provided realtime forecasts
  - Focus on QPF and reflectivity for first 6 h
- DTC conducted evaluation
  - Comparison against
    - HRRR
    - CAPS – cycled start: radar and obs assimilation with cycling
    - CAPS – radar assimilation: Cold-start with radar +obs assimilation
    - CAPS – no assimilation: Cold-start with obs assimilation only
- 2012 experiment: Time to start planning FAB's participation

QPF – 0-6hr accumulation



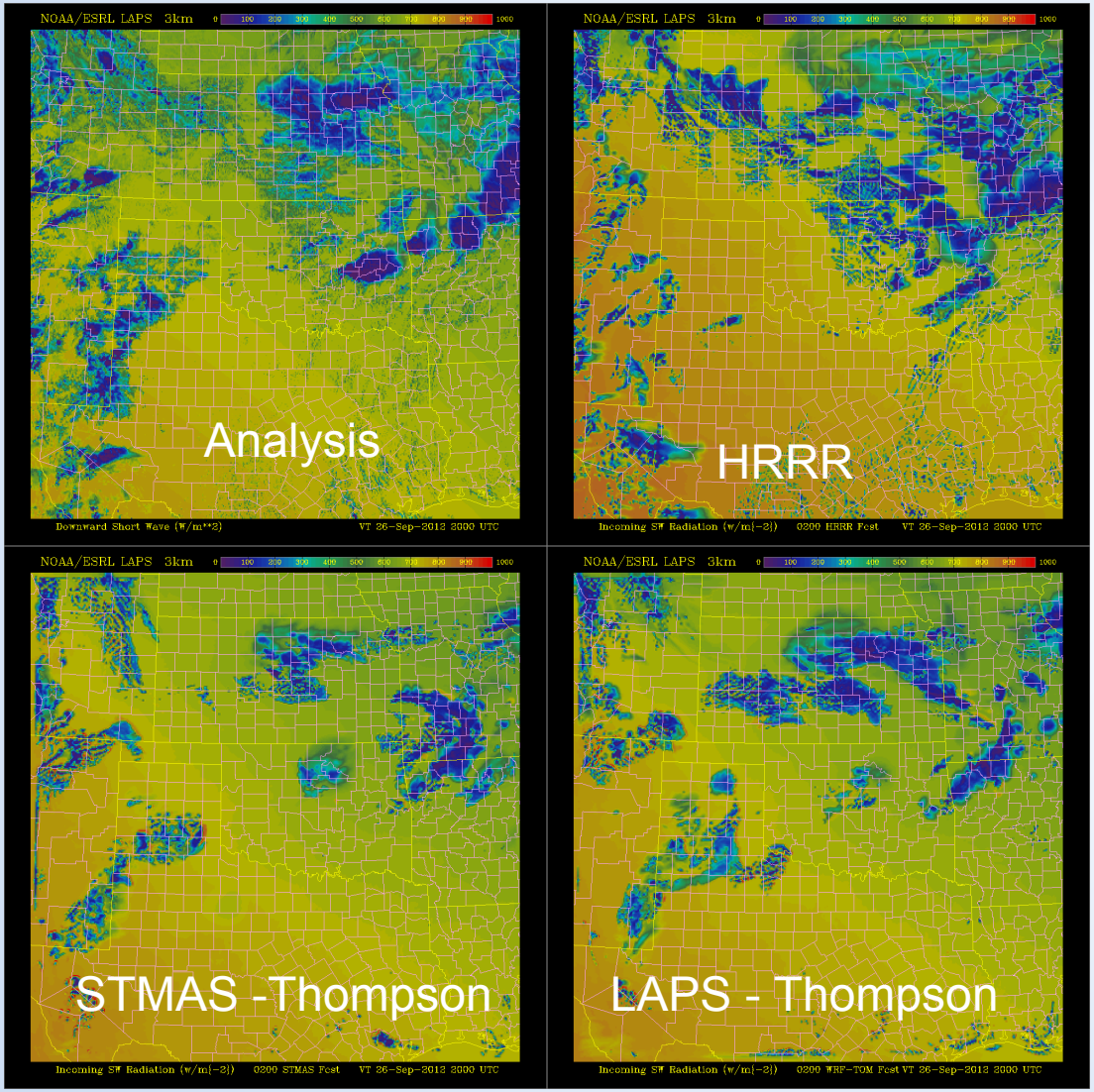


LAPS, HRRR, CAPS (w/ radar assim.) have higher median GSS but overlapping CI notches indicate there is no statistical significance for this sample *(17 homogeneous events or "event equalized").*

All models appear to under-predict QPF events (FBIAS < 1.0). The higher median FBIAS for HRRR and CAPS provide some insight into their GSS trend. They are predicting the "most" forecast events and hence have a higher likelihood of hits. Lower FBIAS for LAPS with wide spread is interesting and worth investigation.

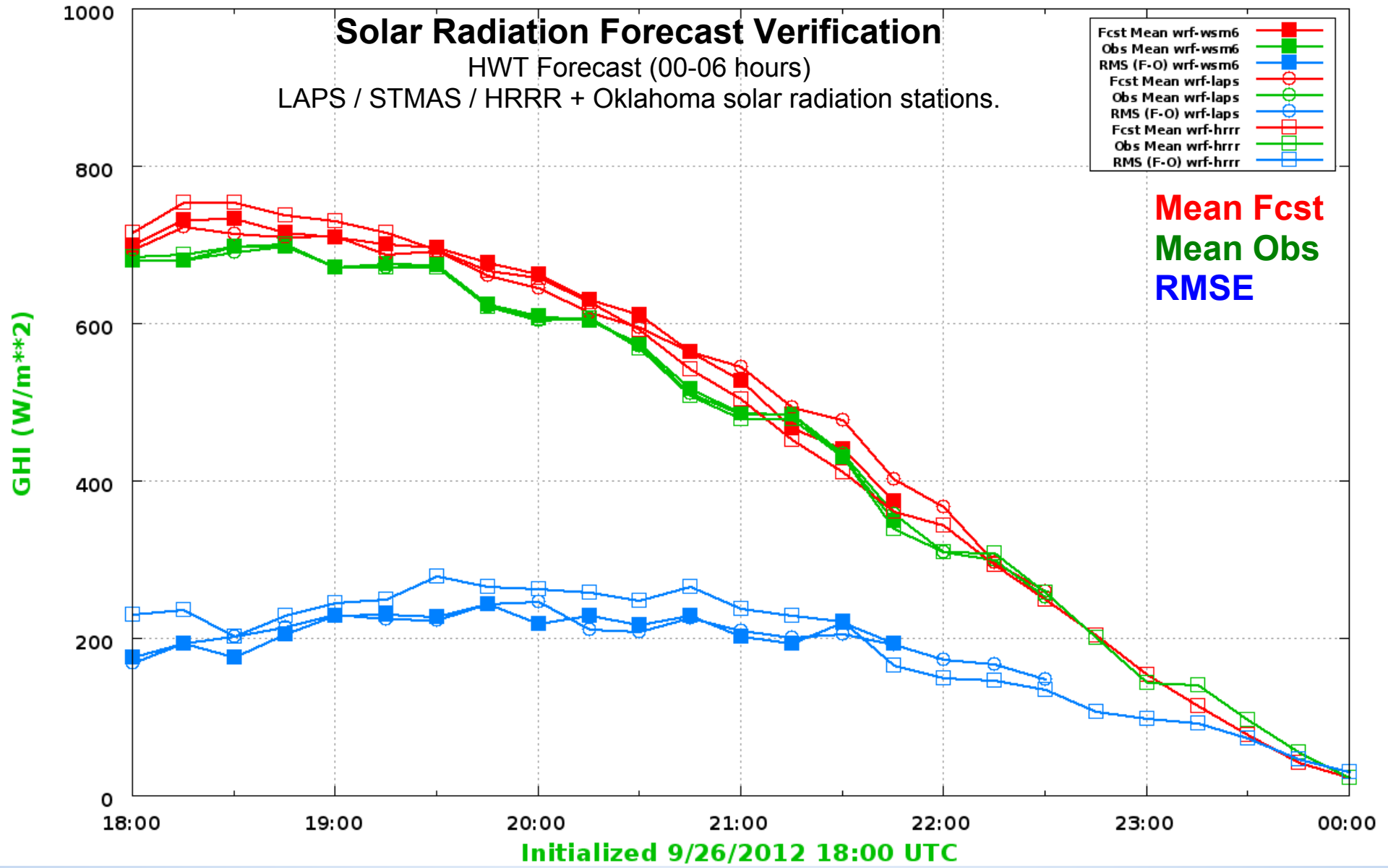
LAPS has widest range of scores (box is largest) suggesting when it's good – it's better than most. When it's bad – it's not quite as good as the other radar assimilation methods**.**

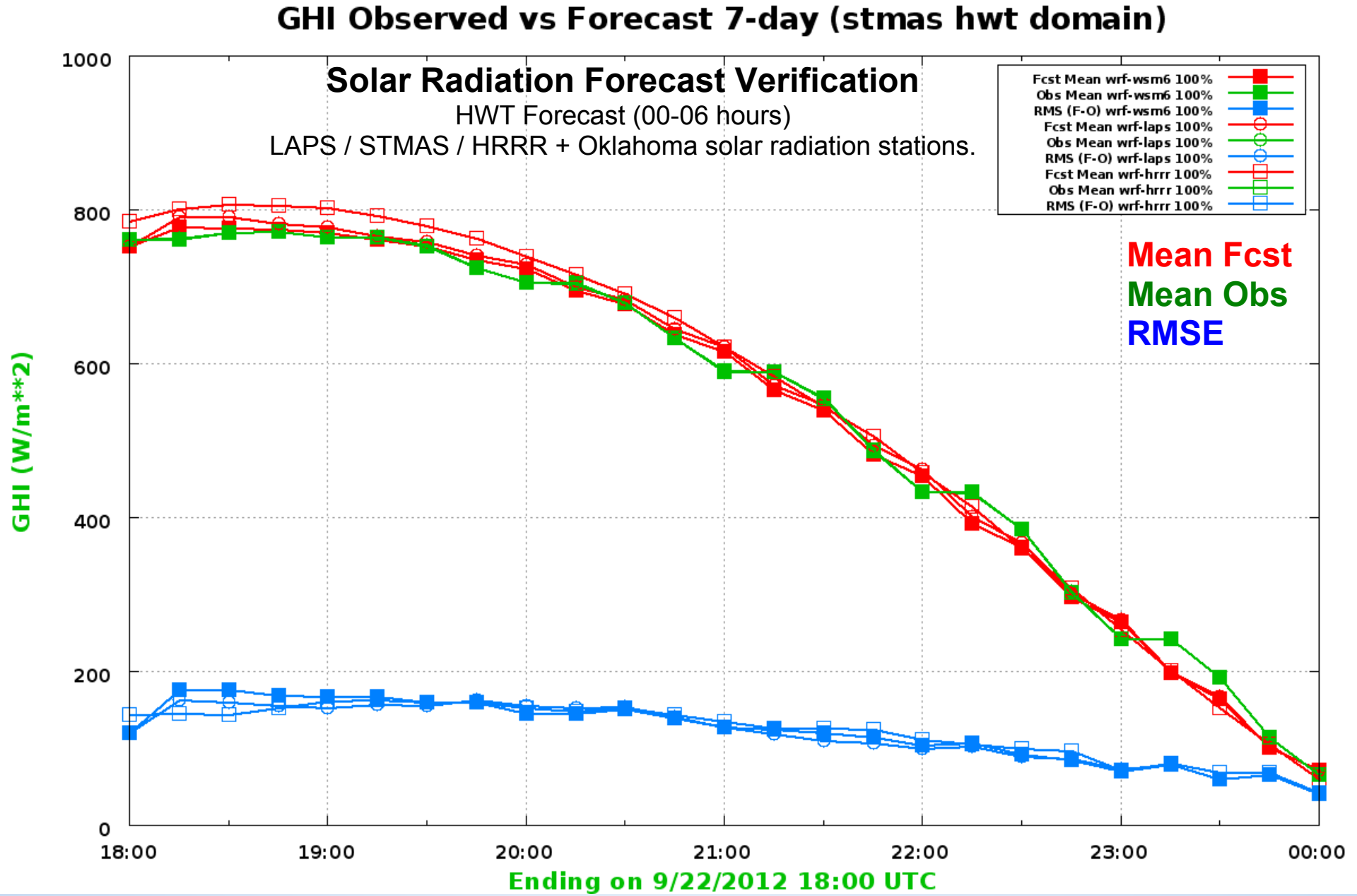
NWP 3: Solar Radiation Forecasting



1800 UTC September 26, 2012
GHI: 02:00 Montage

Global Horizontal Irradiance Observed vs Forecast (stmas hwt domain)




GHI Observed vs Forecast 7-day (stmas hwt domain)
Solar Radiation Forecast Verification
HWT Forecast (00-06 hours)
LAPS / STMAS / HRRR + Oklahoma solar radiation stations.
Fcst Mean wrf-wsm6 100%
Obs Mean wrf-wsm6 100%
RMS (F-O) wrf-wsm6 100%
Fcst Mean wrf-laps 100%
Obs Mean wrf-laps 100%
RMS (F-O) wrf-laps 100%
Fcst Mean wrf-hrrr 100%
Obs Mean wrf-hrrr 100%
RMS (F-O) wrf-hrrr 100%
Mean Fcst
Mean Obs
RMSE
GHI (W/m**2)
1000
800
600
400
200
0
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Ending on 9/22/2012 18:00 UTC

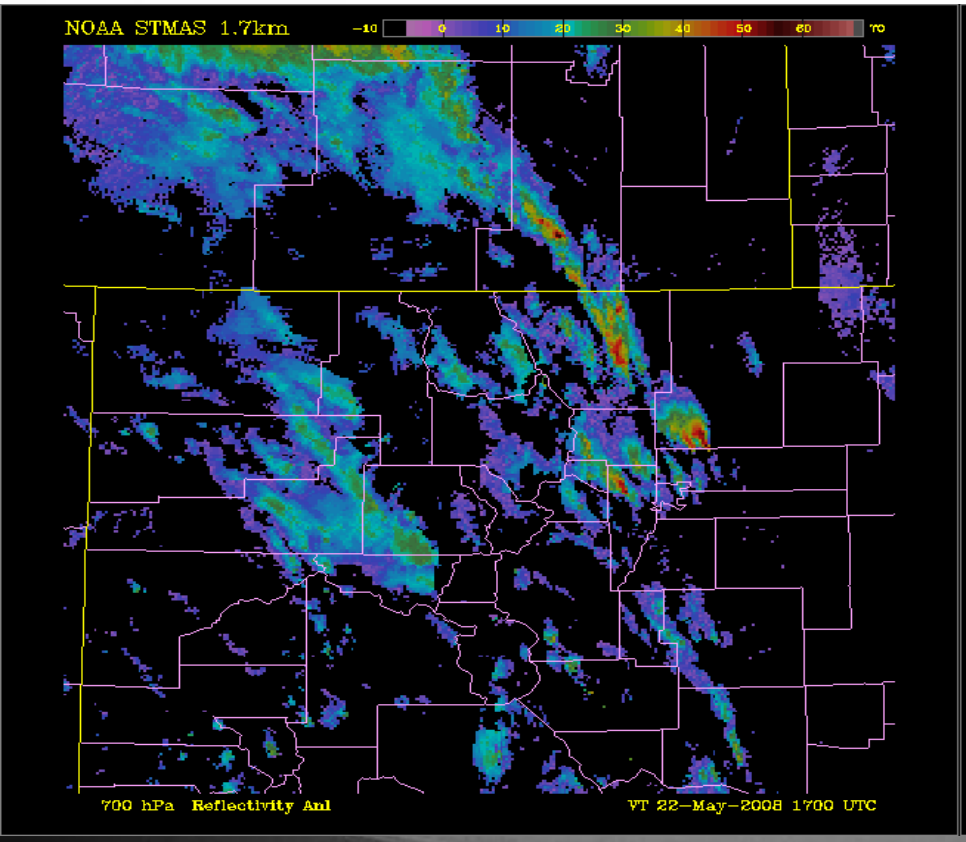
NWP 4: Windsor Tornado Forecasting

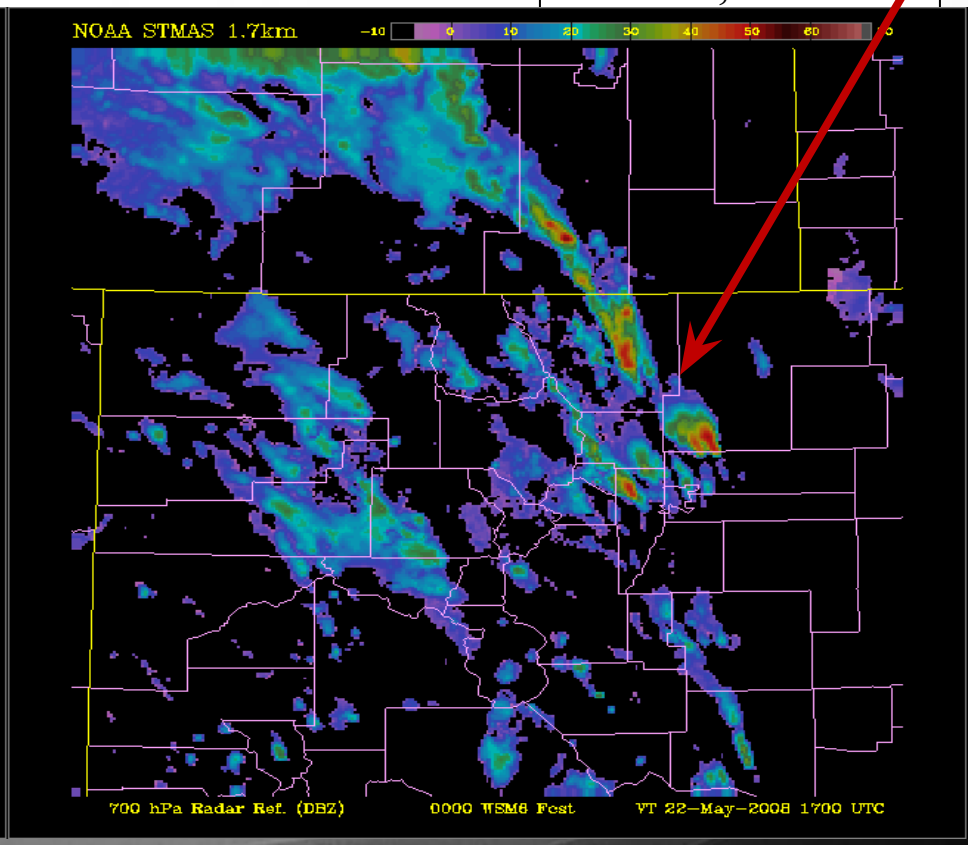
700 mb reflectivity
initial=2008052217, 1h fcst
Mosaic radar vs. WRF forecast (1.6 km res)

Radar / 10 min

Forecast

Improved over 3km run, still west





(Results taken from simulations done by Yuanfu Xie)

Summary of Simulation Results

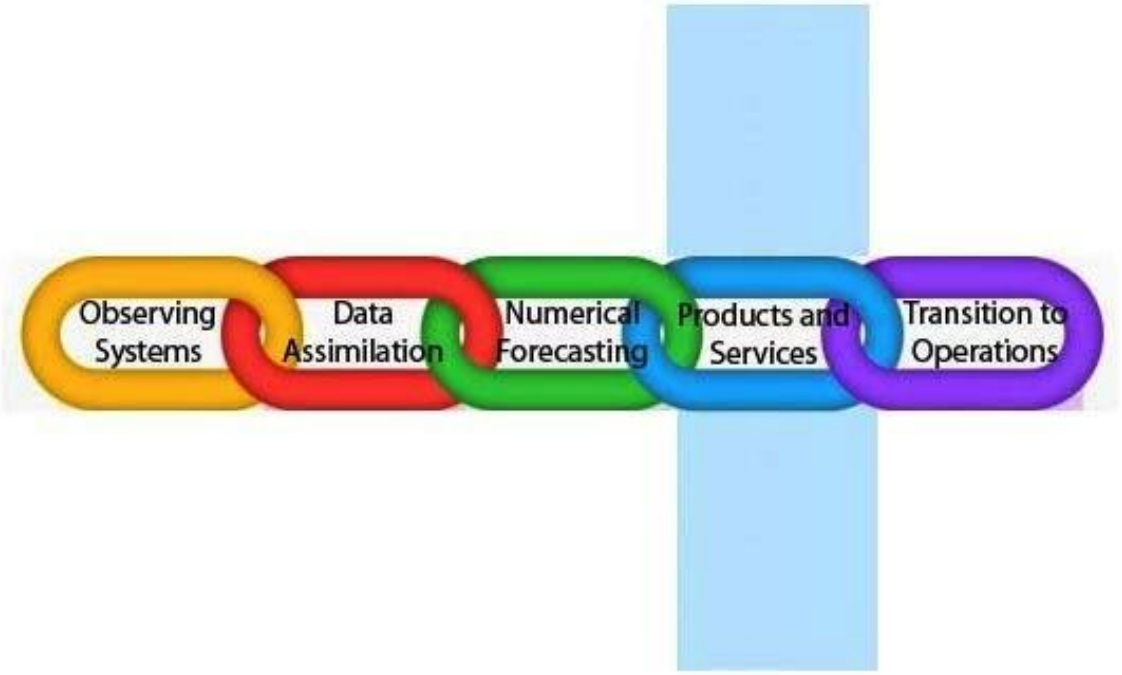
Success:

- From 700 mb reflectivity,12z initialized WRF 3km forecast (not shown), and 17z initialized WRF 1.67km forecast capture the general structure, and orientation
- The maximum reflectivity in 1.67km run is located closer to observations than the 3km simulations
- Microphysics: tom vs. wsm6

Challenges and on-going

- Evaluate other fields, such as Updraft Helicity, Vorticity, Humidity (RH) to understand the results better
- Future plan: Downscale the WRF 3km to 1km, and initialize WRF at 15 UTC or 16 UTC for improved forecast
- Continue to improve the variational LAPS (STMAS) to improve forecast initiation in the Warn-on-Forecast (HWT) environment.

Products and Services



Products and Services

FY12

HFIP Products

- Unification of TC Products pages for NHC, etc

FAB Products

- HMT Upslope
- Others

FAB Services

- Statistical post-processing that FAB applies and develops will improve quality of products and services
- Service offered to users (in place of cookie cutter product), can get via dynamical web or interface, etc
- Example

FY13

FDSE

NextGen

http://hfip.org/products

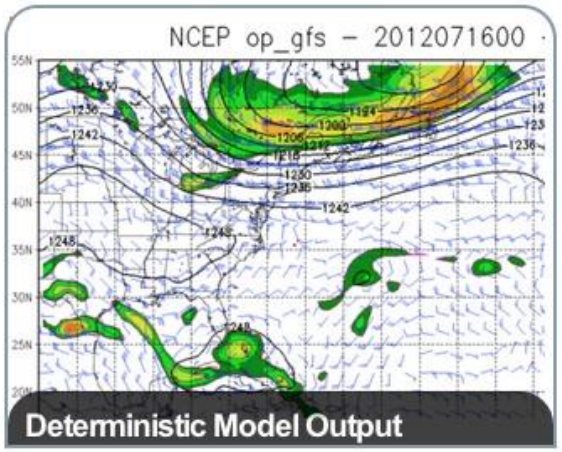
HFIP Products | HFIP Hurricane Forecast Improvement Program | NOAA

HFIP Experimental Products

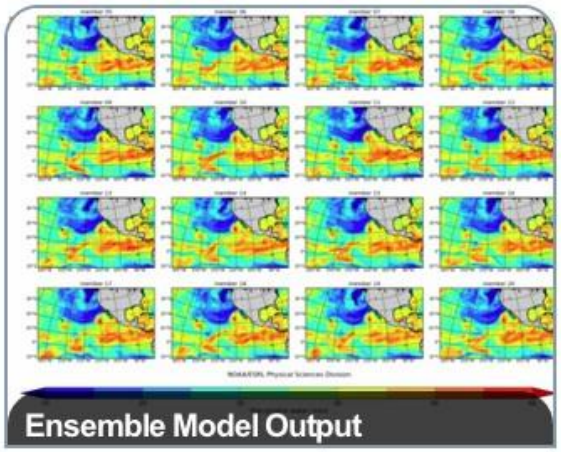
WARNING: These webpages contain experimental analysis and forecast guidance of unknown accuracy and reliability.
This guidance is not intended to replace official advisory, forecast, and warning products issued by the National Hurricane Center and your local National Weather Service Forecast Office. Outside of the United States, please also refer to products issued by your national meteorological service.
For official forecasts consult the National Hurricane Center

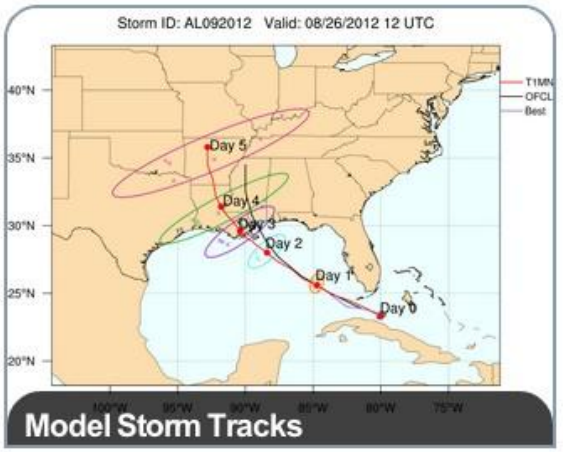
~~~ Note: US HFIP forecast products are created Aug 1 through Nov 1 ~~~

→ HFIP Product Overview ←

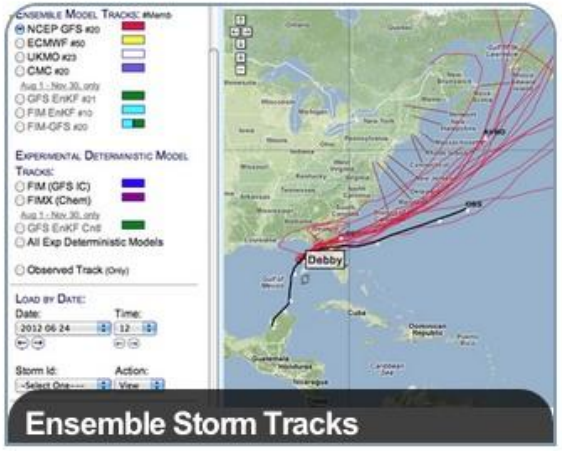


Deterministic Model Output

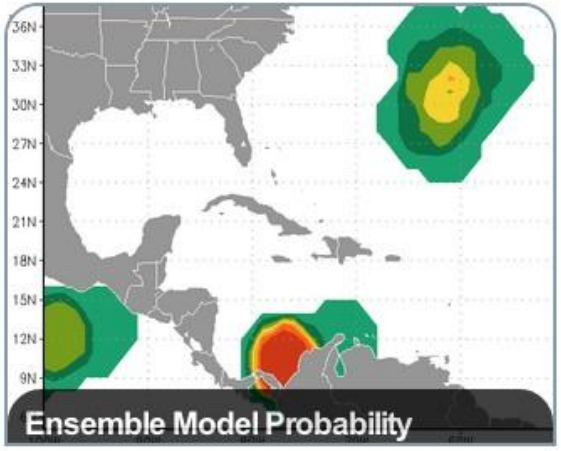

Ensemble Model Output

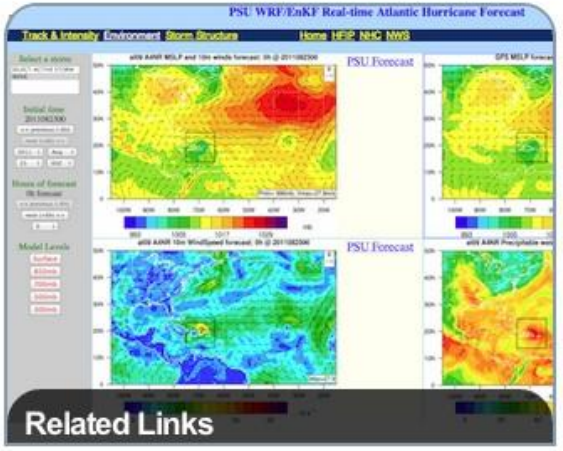


Model Storm Tracks



Ensemble Storm Tracks


Ensemble Model Probability



Related Links
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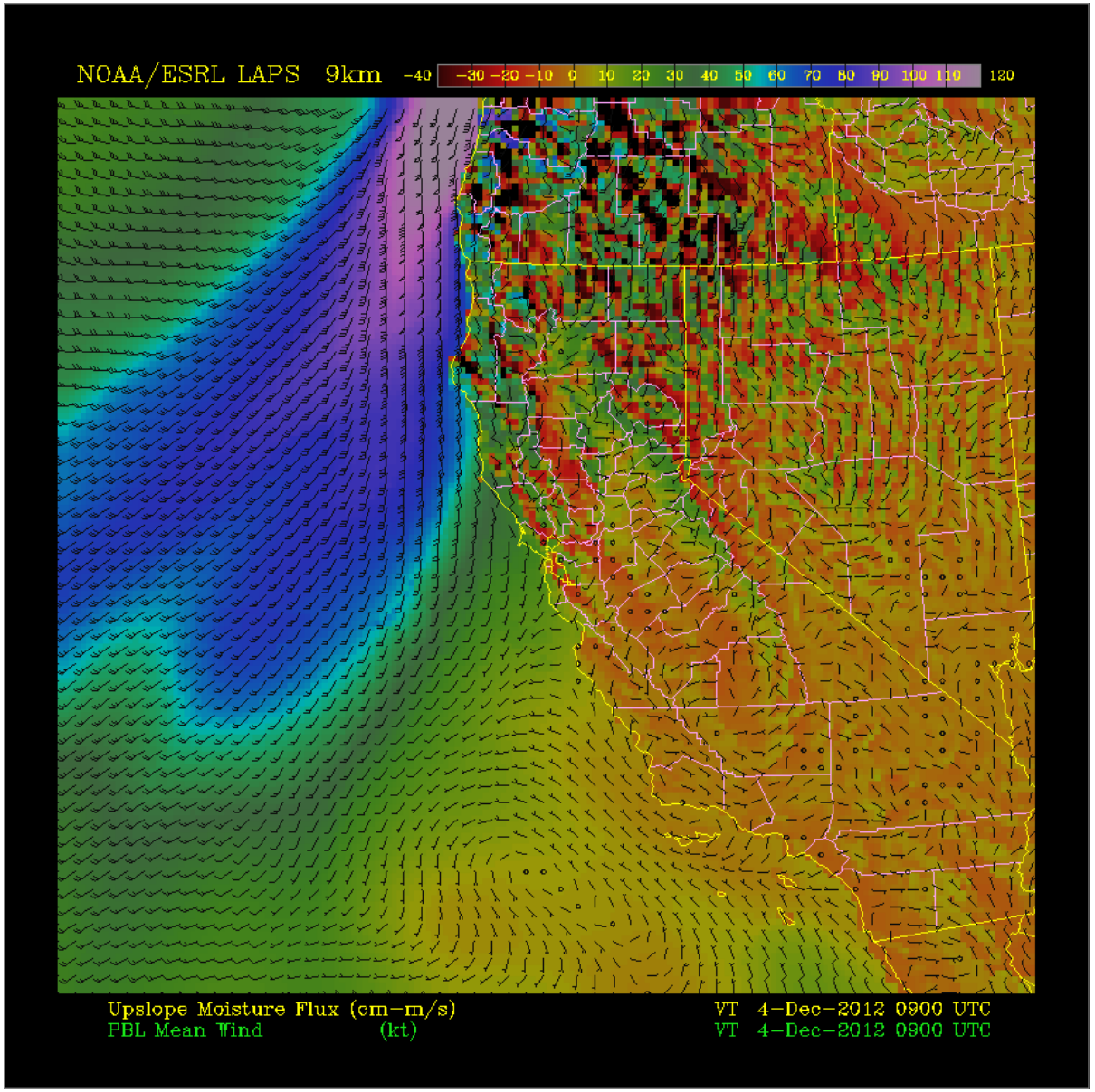
http://laps.noaa.gov/cgi/laps/domains/dwr/



Wesley Smith, Zoltan Toth, and Paula McCaslin

HFIP – FAB Statistical Post-Processing

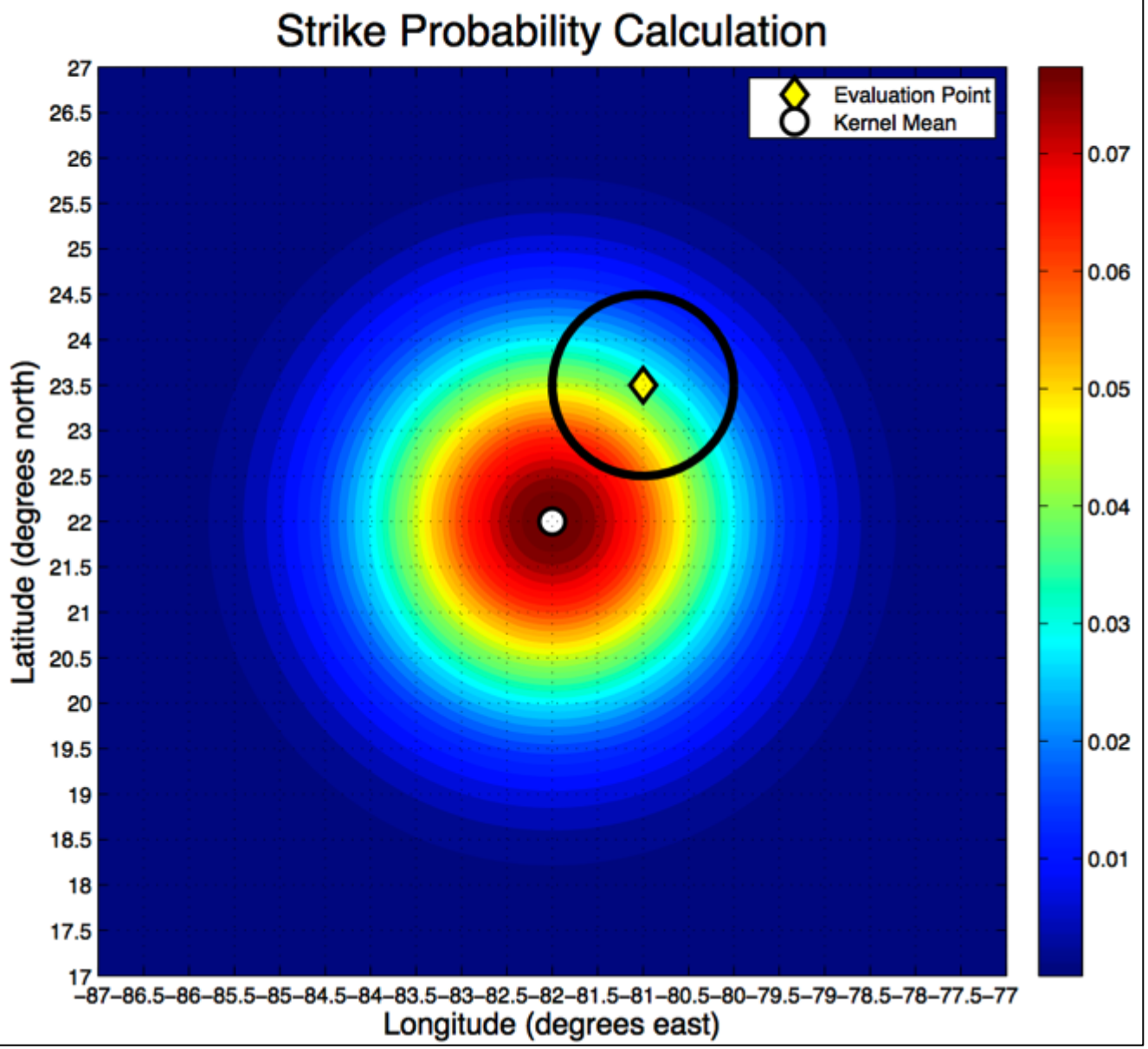
- Strike probability and track forecast cones each describe the probability of a single event (storm will be located within a 60 n mi radius)

- A storm position pdf (SPPDF) forecast is a more general approach describing the probability of all events related to storm position.

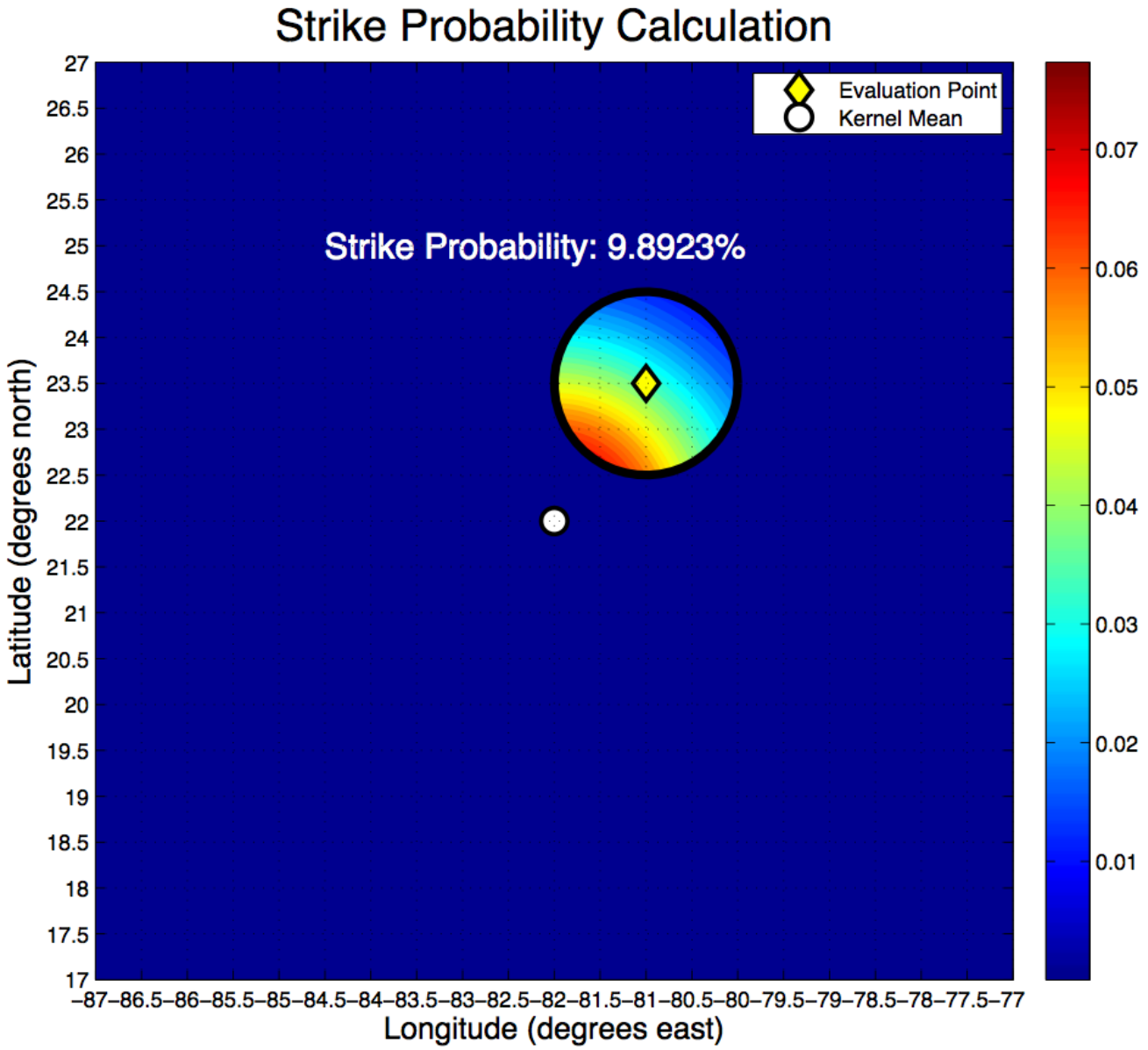
- Users may be interested in the probability of storm passing within their state or county. They can obtain this information if they have access to a storm position pdf.

HFIP – FAB Statistical Post-Processing

Example: 2D PDF

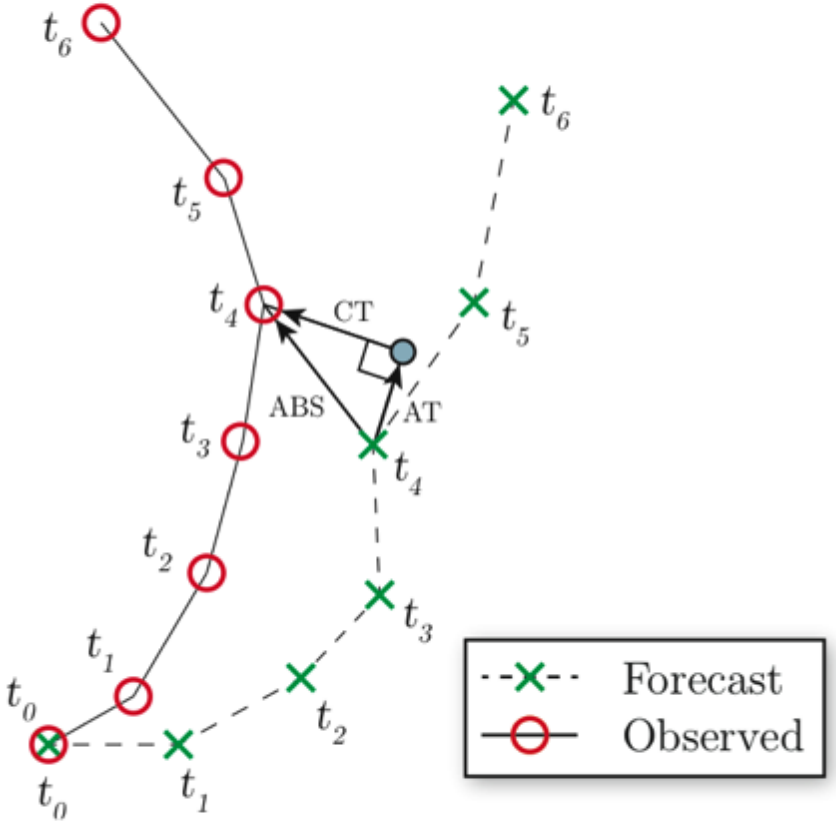


Example: 2D PDF



Proposed Method: Track Errors

- An SPPDF is constructed from an ensemble forecast and is based on historical error statistics.
- These historical errors are seperated into **along-track** (timing) and **cross-track** (position) components.
- All errors are great circle distances, accounting for the curvature of the Earth's surface.



Proposed Method: Best Members

- For a given forecast case, we can determine a **best member**, which is closest to the observed track *in that case*.

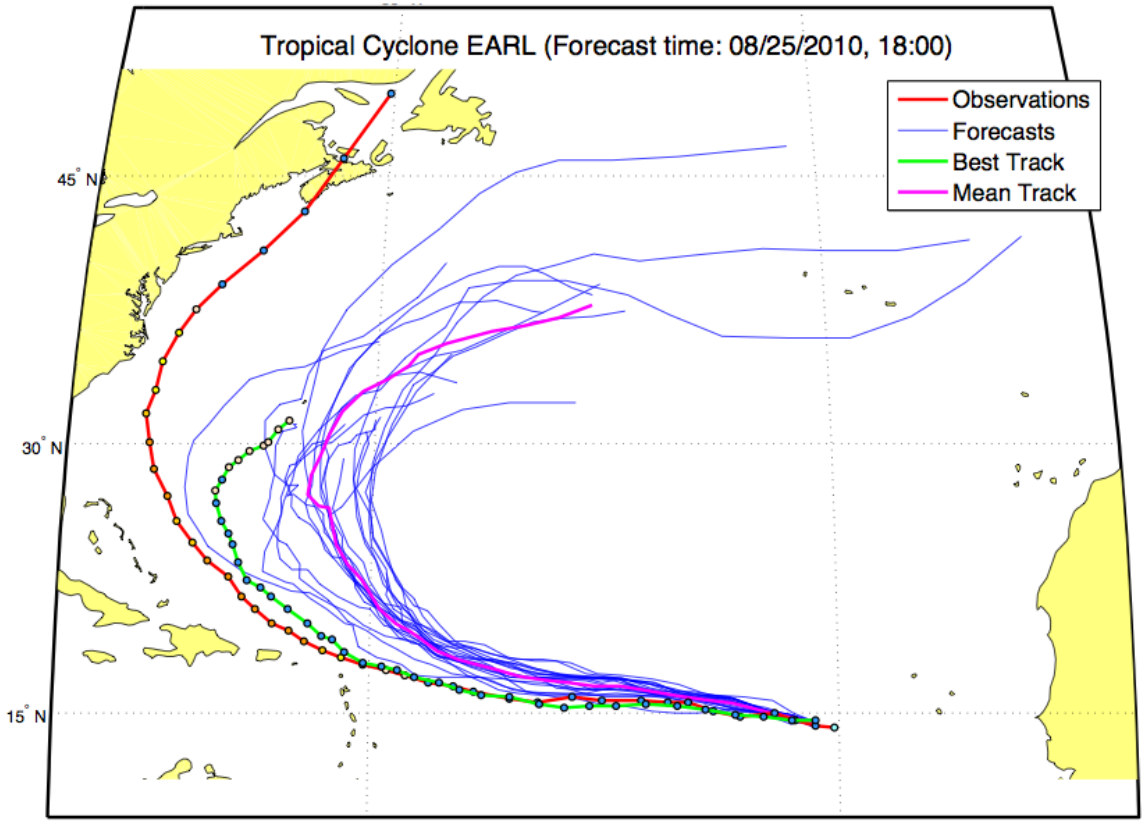
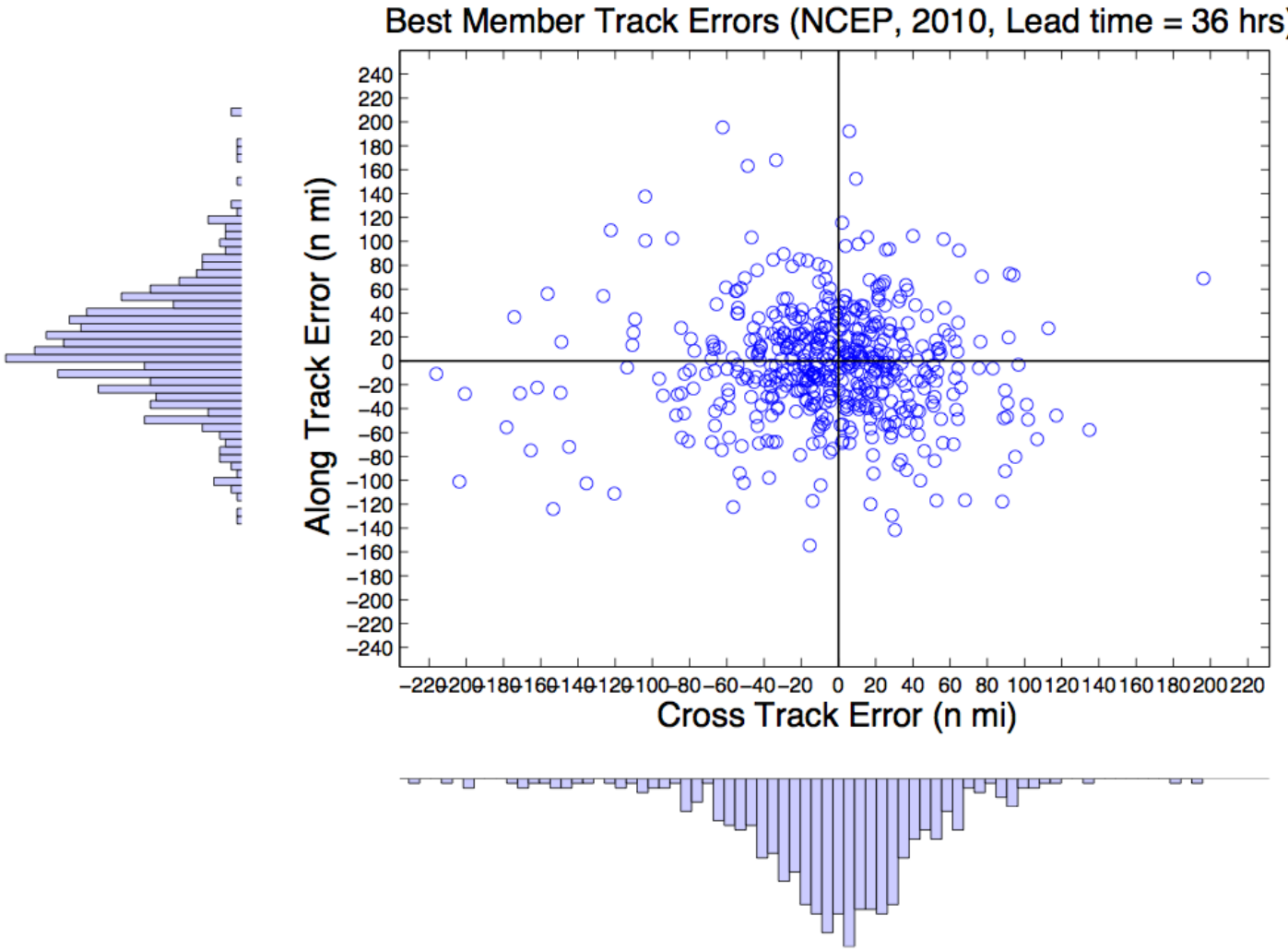


Figure: Forecast case for Hurricane Earl at 08/25/2010, 6:00 pm.

Example: Aggregated Errors

- 2-dimensional normal distributions can be fit to error statistics of best members aggregated over a period of time.



Example: Hurricane Irene (Initial time)

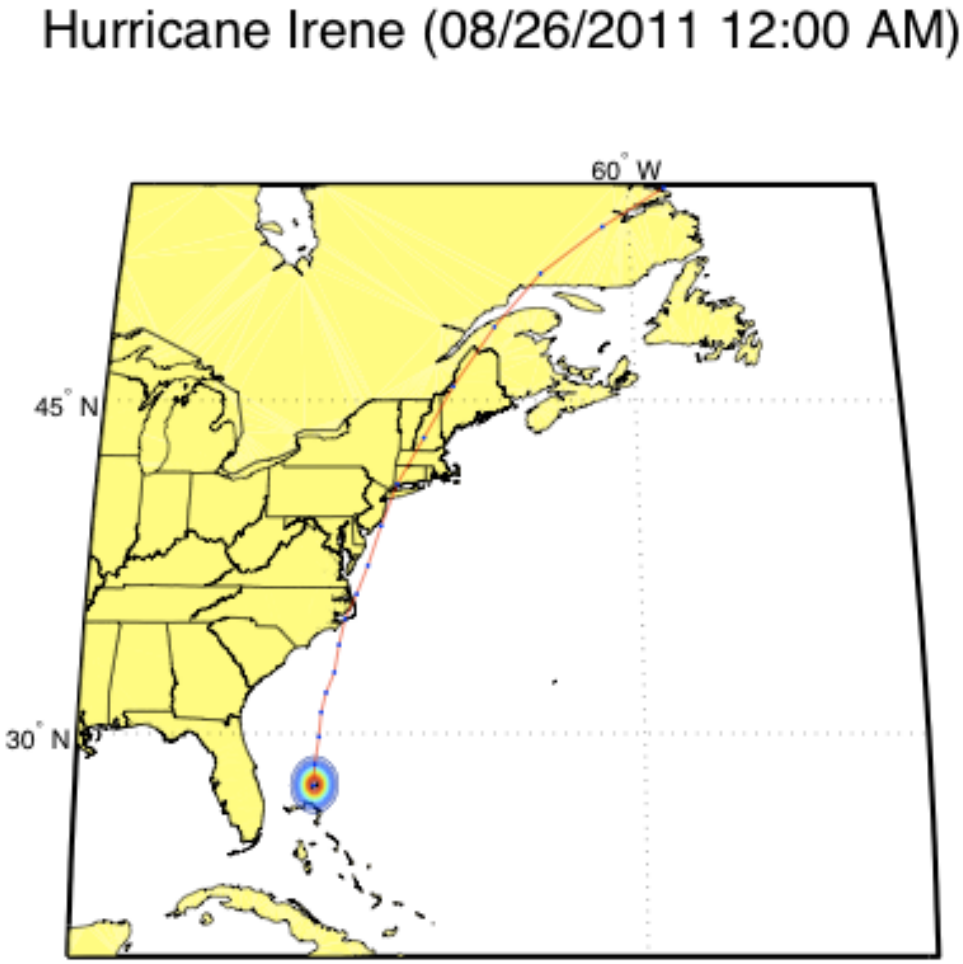


Figure: GEFS 20-member ensemble mean and storm position probability distribution at the initial time.

Example: Hurricane Irene SPPD (12 hrs)

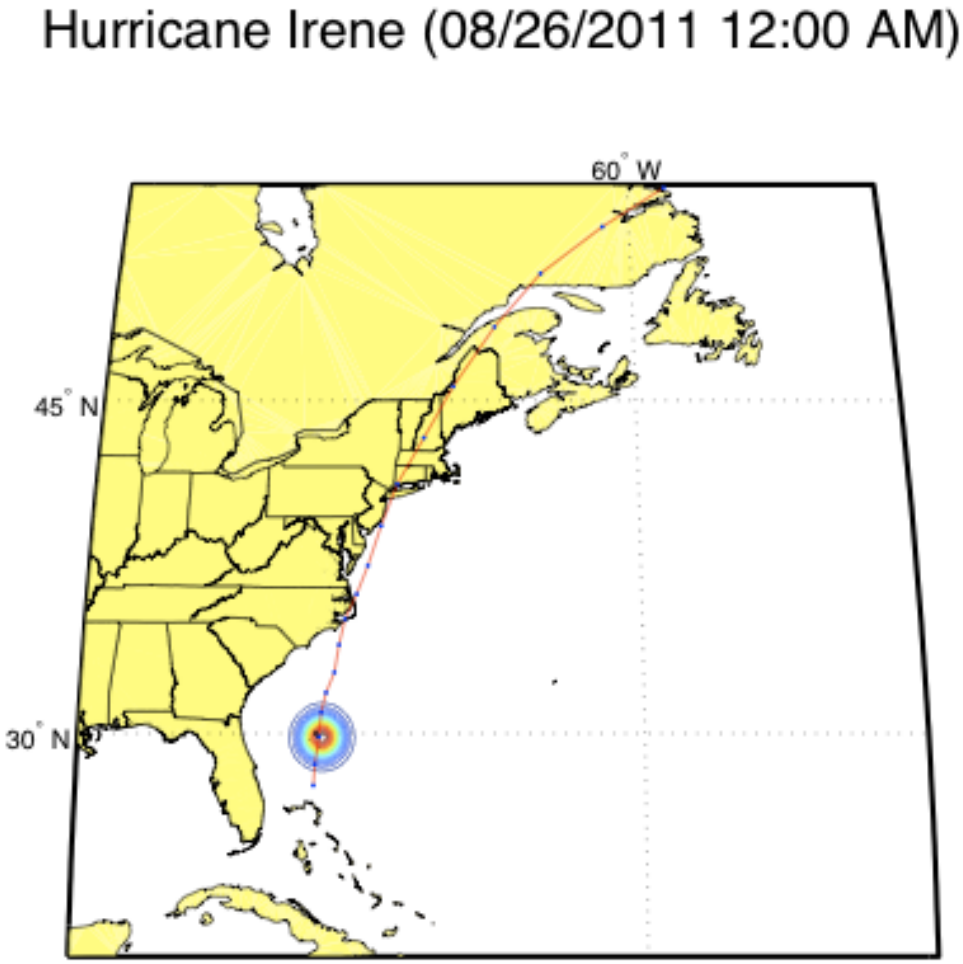


Figure: GEFS 20-member ensemble mean and storm position probability distribution at 12 hours of lead time.

Example: Hurricane Irene SPPD (24 hrs)

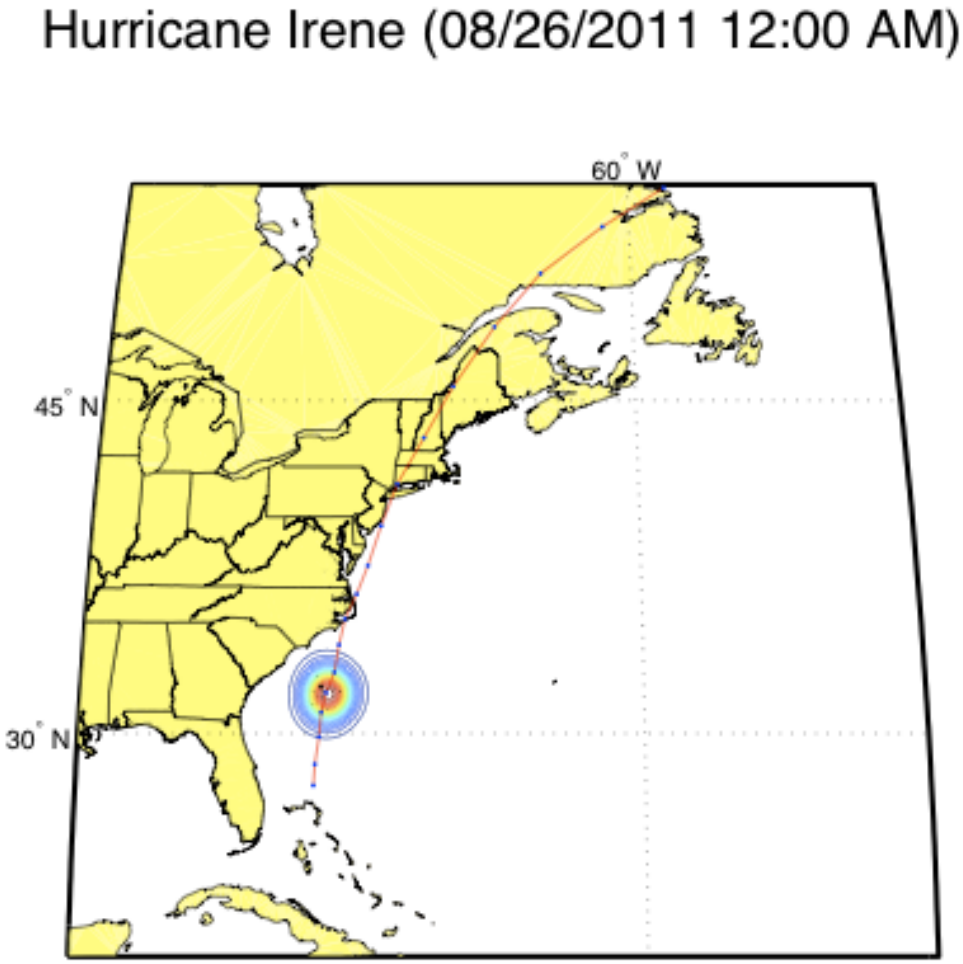


Figure: GEFS 20-member ensemble mean and storm position probability distribution at 24 hours of lead time.

Example: Hurricane Irene SPPD (36 hrs)

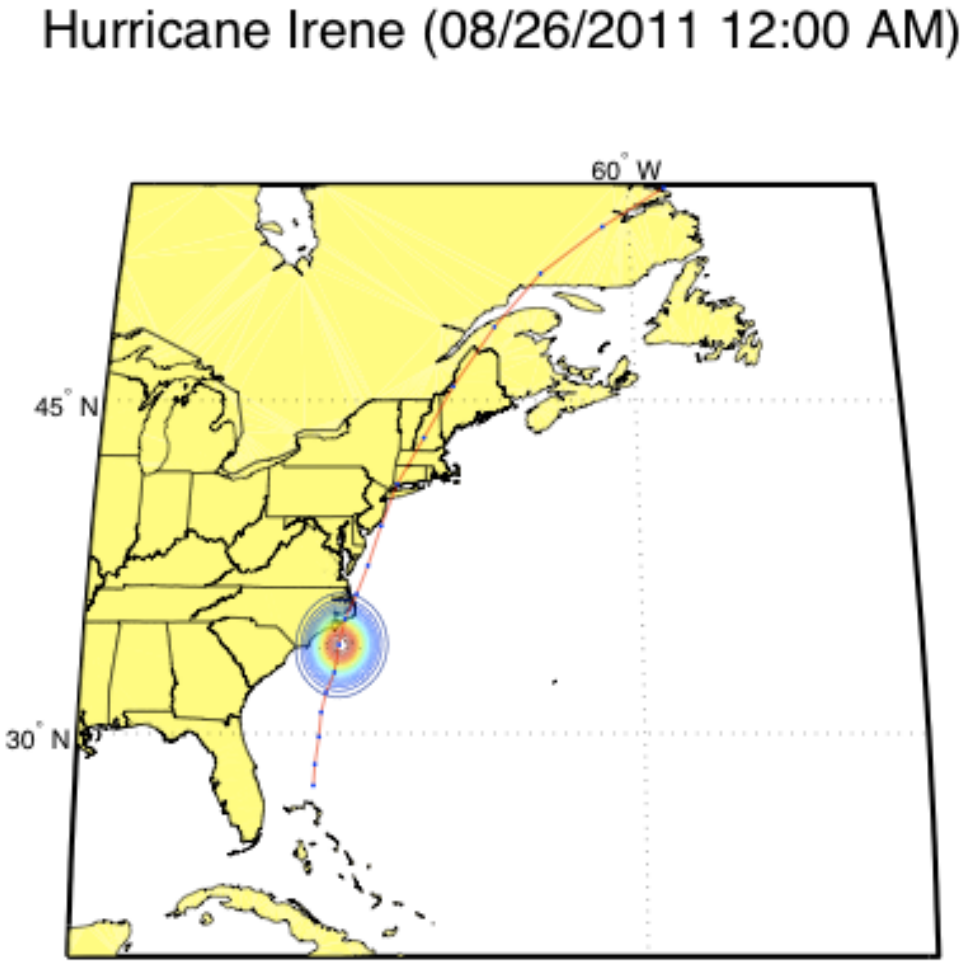


Figure: GEFS 20-member ensemble mean and storm position probability distribution at 36 hours of lead time.

Example: Hurricane Irene SPPD (48 hrs)

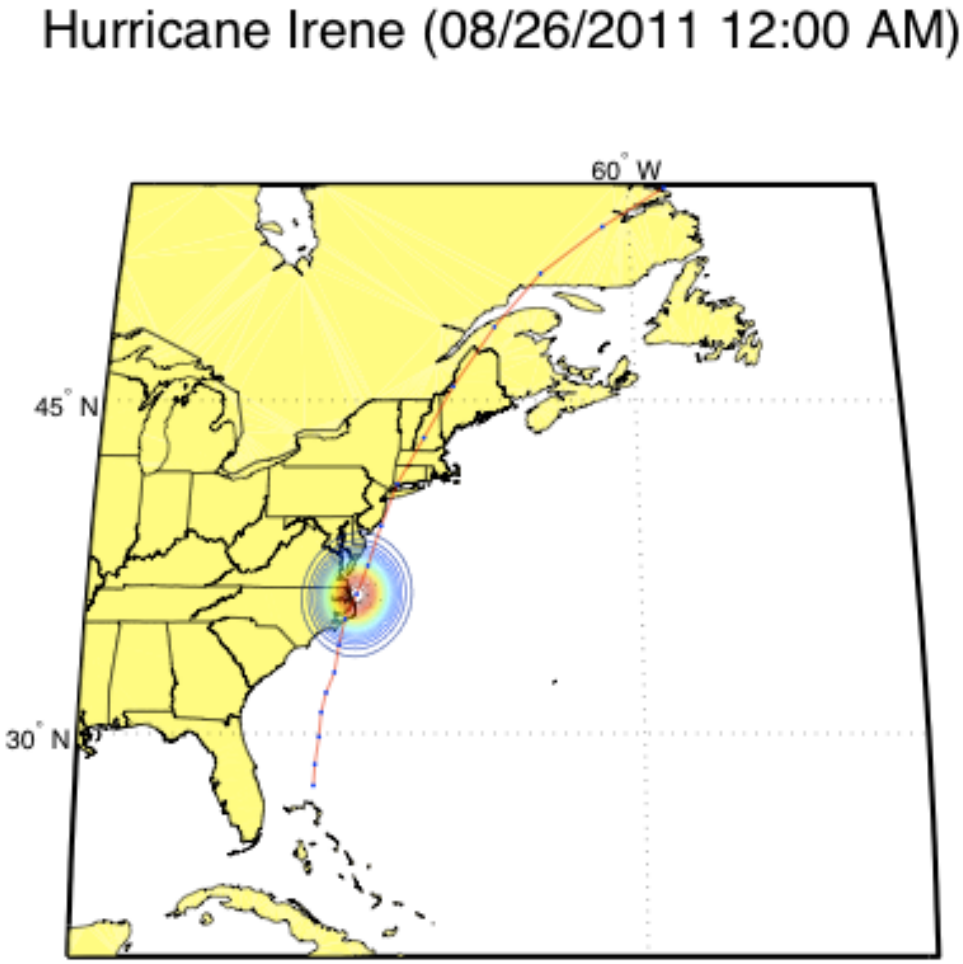


Figure: GEFS 20-member ensemble mean and storm position probability distribution at 48 hours of lead time.

Example: Hurricane Irene SPPD (60 hrs)

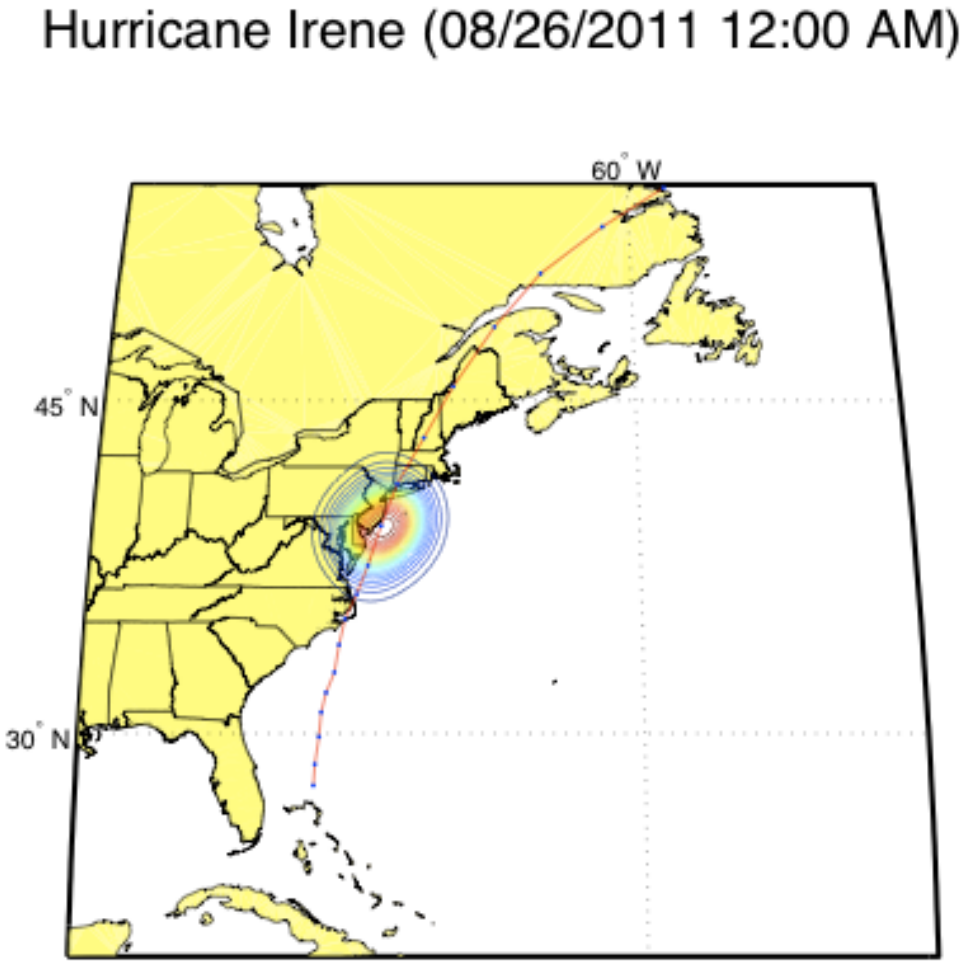


Figure: GEFS 20-member ensemble mean and storm position probability distribution at 60 hours of lead time.

Example: Hurricane Irene SPPD (72 hrs)

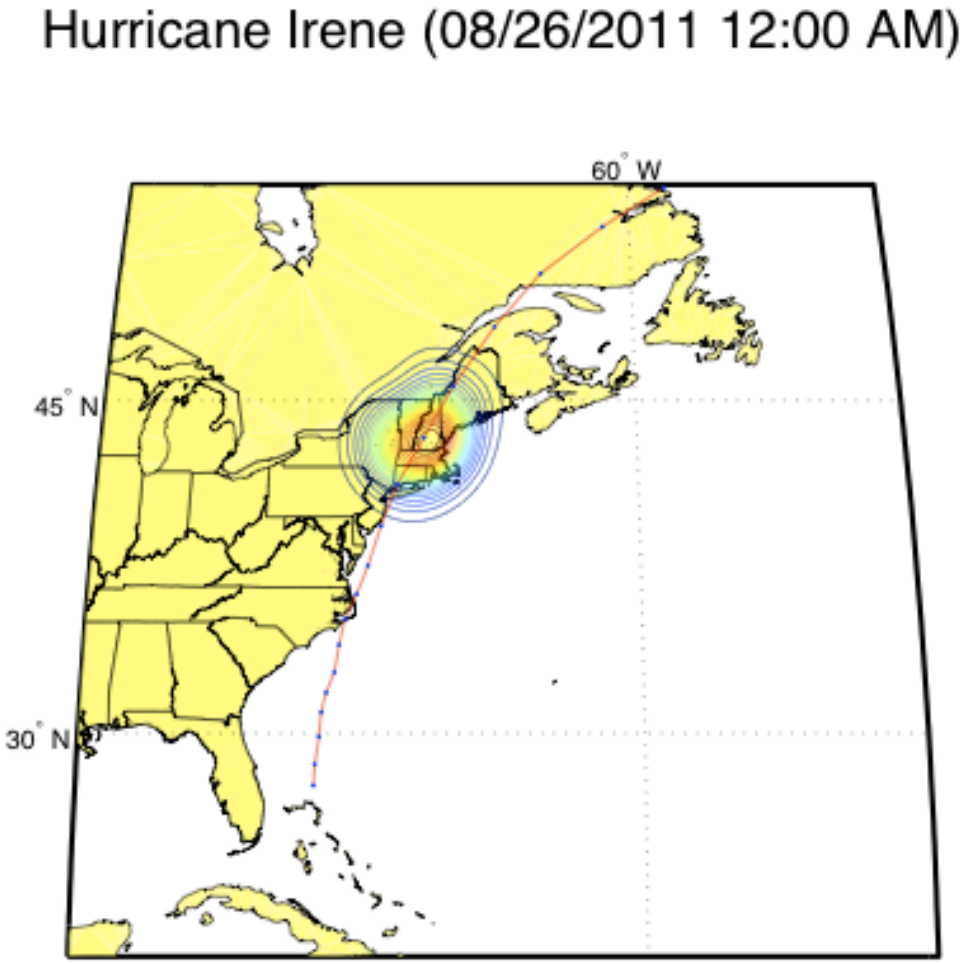


Figure: GEFS 20-member ensemble mean and storm position probability distribution at 72 hours of lead time.

Example: Hurricane Irene SPPD (84 hrs)

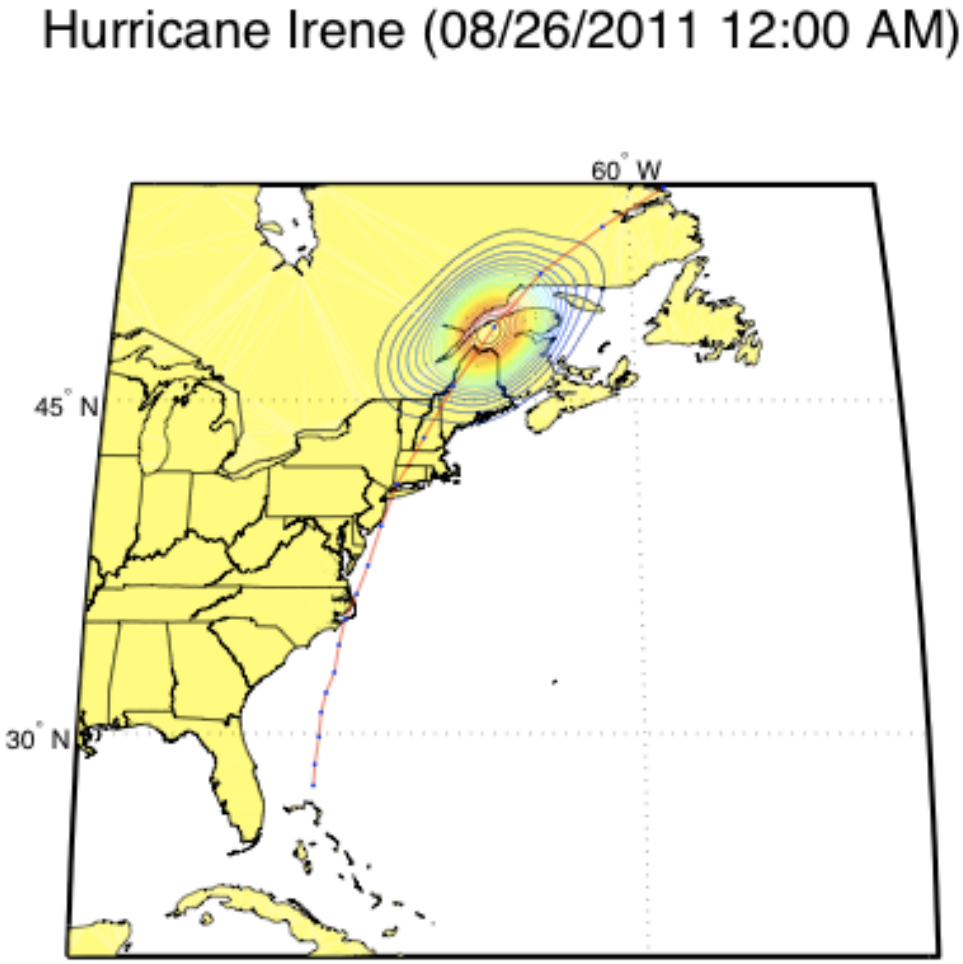


Figure: GEFS 20-member ensemble mean and storm position probability distribution at 84 hours of lead time.

SUMMARY

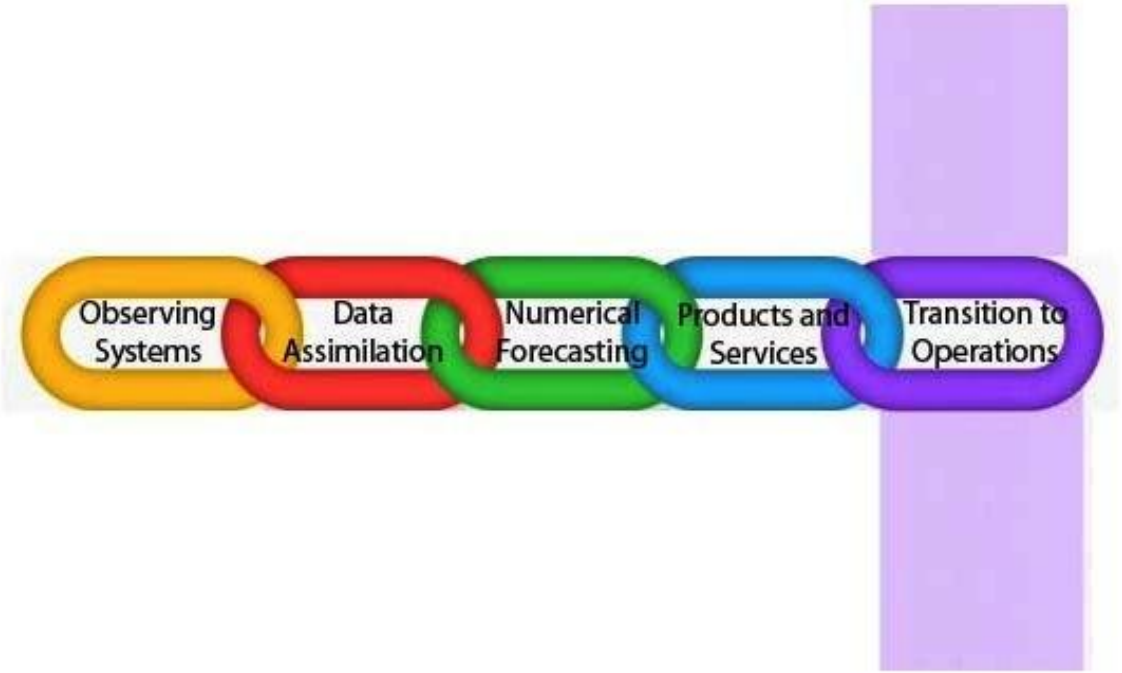
- FAB Ongoing SPPDF Work
  - Verification, 2-D continuous rank probability scores
  - Application to multi-model ensembles
  - Comparison with NHC track forecast cones

IMPROVED NUMERICAL GUIDANCE FOR AIVs

- Objective
  - –Provide high quality fine scale 3D grids for AIVs - FDSE / NextGen Funding
- Data source
  - –Ensemble forecasts; Use HMT ensemble as testbed – easily available to developers
- Statistical post-processing
  - –Necessary due to systematic errors in input ensemble data
  - –Successive applications – Fix largest problem(s) first
    - Recursive filters to estimate biases in mean & spread
    - Link with NEAFS statistical post-processing methods at NCEP
    - Bayesian methods to incorporate latest observations
      - –Univ. Virginia and possibly MDL collaboration
- Proxy for (3D) truth
  - –Fine scale, observationally based 3D NWP analysis
  - –LAPS as testbed – only such analysis available now at NOAA

Methods developed and tested can be applied to any ensemble and analysis datasets

Transition to Operations

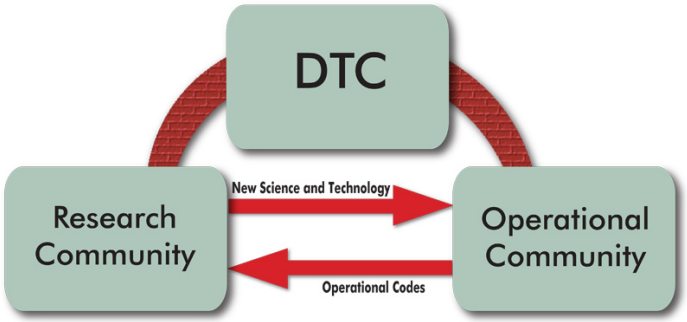


Developmental Testbed Center (DTC) activities

DTC Mission

The fundamental purpose of the DTC is to facilitate the interaction & transition of NWP technology between research & operations. DTC facilitates:

- R2O transition by performing testing & evaluation of NWP innovations in a functionally-similar operational environment
- O2R transition by making operational NWP systems available to the research community & providing user support
- Interaction between research and operations through NWP workshops/meetings and the DTC Visitor Program



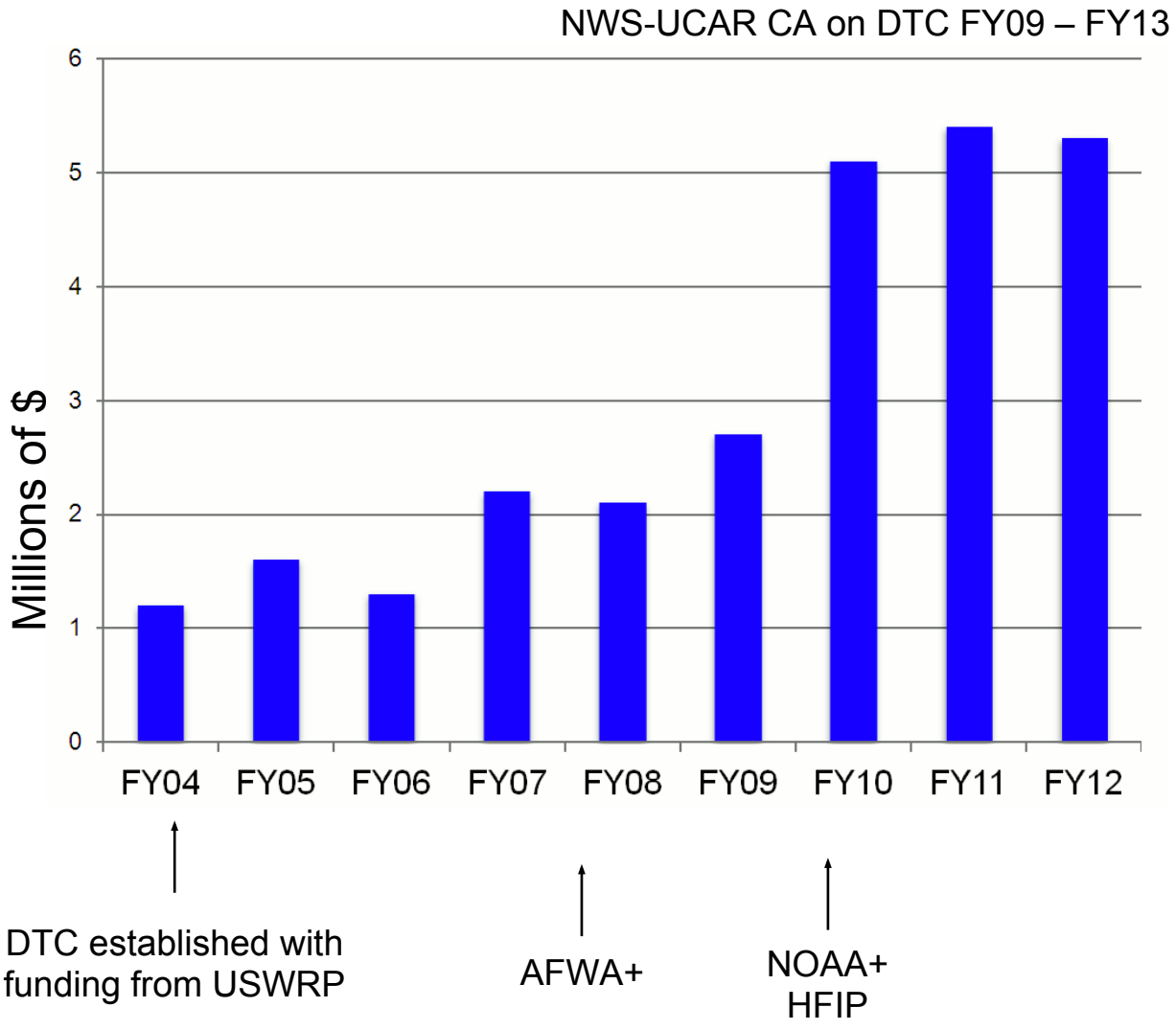
DTC Overview

- The DTC Charter provides guidance for the governance
  - DTC Management Board: helps prepare DTC AOP and budget
  - DTC Executive Committee approves the AOP and budget.
  - DTC Science Advisory Board (SAB) provides recommendations on codes/systems to be tested, visitor program, and future direction of DTC.
- DTC was established in 2003, with funding from USWRP.
- Coop Agreement (5y): signed with NCAR in 2009. NOAA is now preparing an announcement for re-competition.
- Dedicated NOAA-OAR funding (3 mil) started 3 years ago.
- FY2012: DTC budget is $5.3 M, with funding provided by OAR, GSD, NWS/HFIP, USWRP, Air Force, NSF, NCAR.

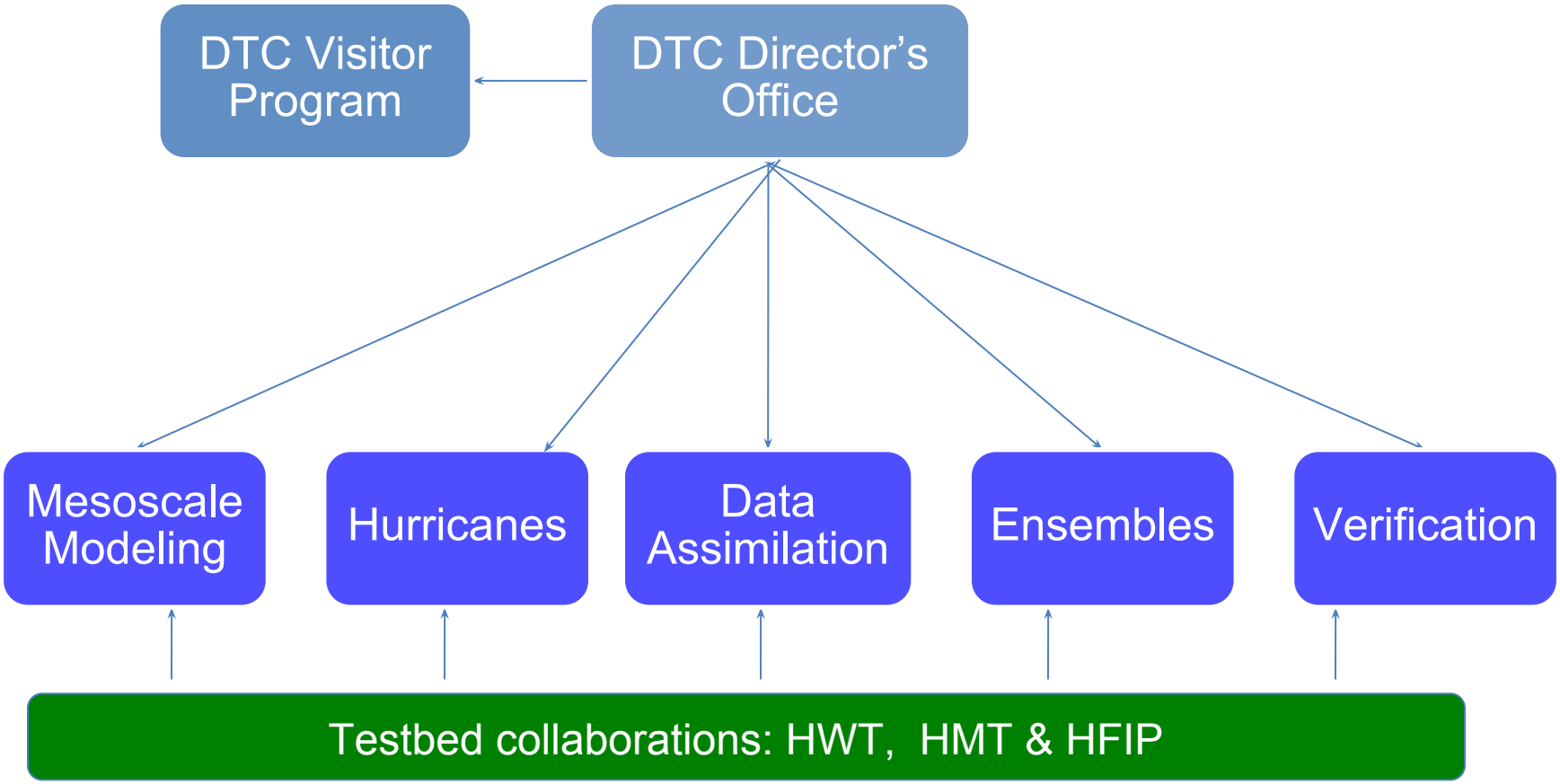
DTC budget
Sources: NOAA, AFWA, NCAR, NSF

2012 Staff: ~45 (total of ~25 FTE), distributed between NOAA/ESRL/ GSD (1/3), and NCAR (2/3).

The DTC Director's Office is hosted at NCAR/RAL.



DTC Task areas



1. DTC activities focused on five key areas: Mesoscale Modeling, Hurricanes, Data Assimilation, Ensembles and Verification.
2. HWT, HMT, and HFIP are cross-DTC special projects that contribute to identified focus areas.

Code releases and community interactions

Package	Code releases	Onsite Tutorials	Registered Users 2009	Registered Users 2012
WRF/UPP	1 Major - Apr 1 Minor – Aug	Bi-annual → Annual	~1,400*	15,700*
HWRF	1 Major	Semi-Annual	0	430
GSI	1 Major	Annual	0	581
MET	2 Major	Bi-annual → Annual	~300	~1,800

DTC supports NWP systems to the community and provides:

- code releases
- documentation
- test datasets
- benchmarks
- tutorials

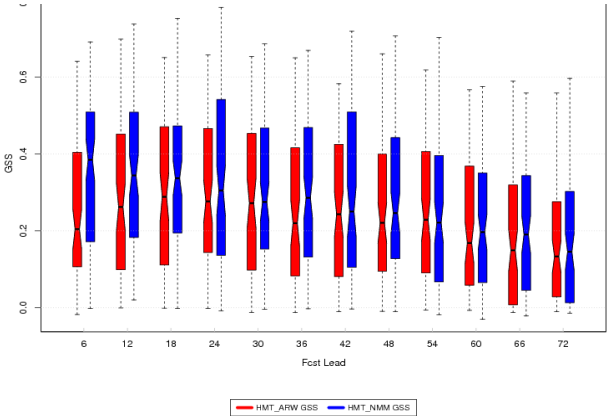
DTC provides code management: clear path of research code to operations

2009-12 DTC-sponsored events: WRF users workshop, workshop on model physics, high-resolution hurricane workshop, hurricane science days, GSI data assimilation workshop, workshop on probabilistic prediction, DTC ensemble testbed workshop, NCEP ensemble user workshop, workshop with GIFS-TIGGE, forecast verification workshops

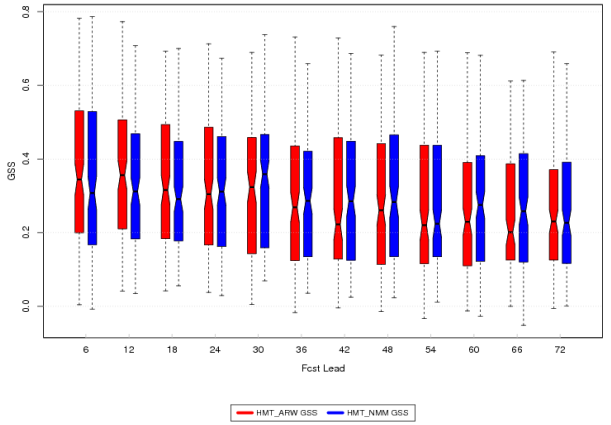
Highlight 1: DTC Evaluation of FAB HMT forecasts

- During the 2011-2012 winter, FAB ran an ensemble to support the Hydrometeorology Testbed exercise
- DTC performed verification
- ARW ensemble model members (red) were hot-started using LAPS during the period March 15-April 15, but were not hot-started before that.
- The NNM members (blue) were not hot started during either period.
- Results show positive impact of LAPS hotstart on ARW

GSS 1/15-2/15 (w/o hot start)



GSS 3/15-4/15 (with hot start)

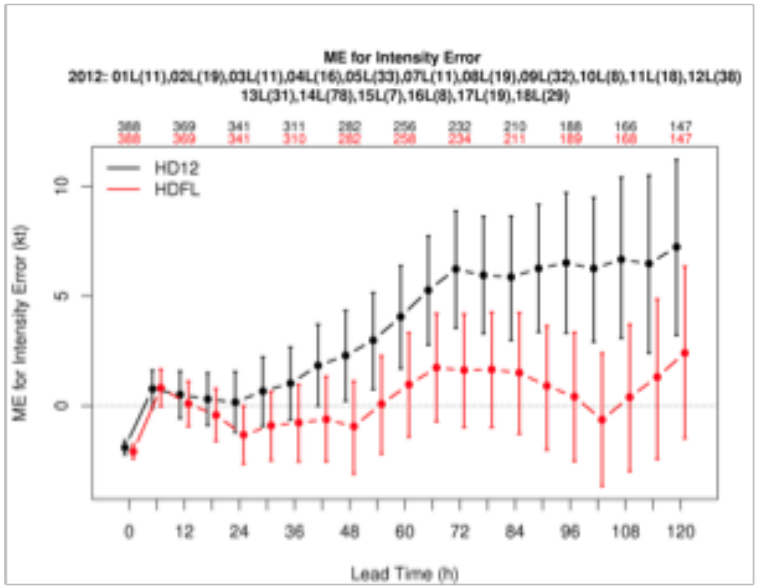


Highlight 2: DTC test of HWRF with modified fluxes atmos to ocean

NOAA AOML/HRD compared HWRF 2011ocean forecasts against buoy data and showed that HWRF does not respond enough (does not cool when storm goes by)

DTC (with AOML/HRD, NCEP/EMC, and URI) designed an experiment to modify the momentum flux that is transferred to the ocean

DTC reran entire 2012 season (AL and EP) to obtain results to support EMC in their 2013 HWRF implementation. Results likely to be adopted in both HWRF and GFDL operational models (according to NCEP Product Suite Review yesterday)

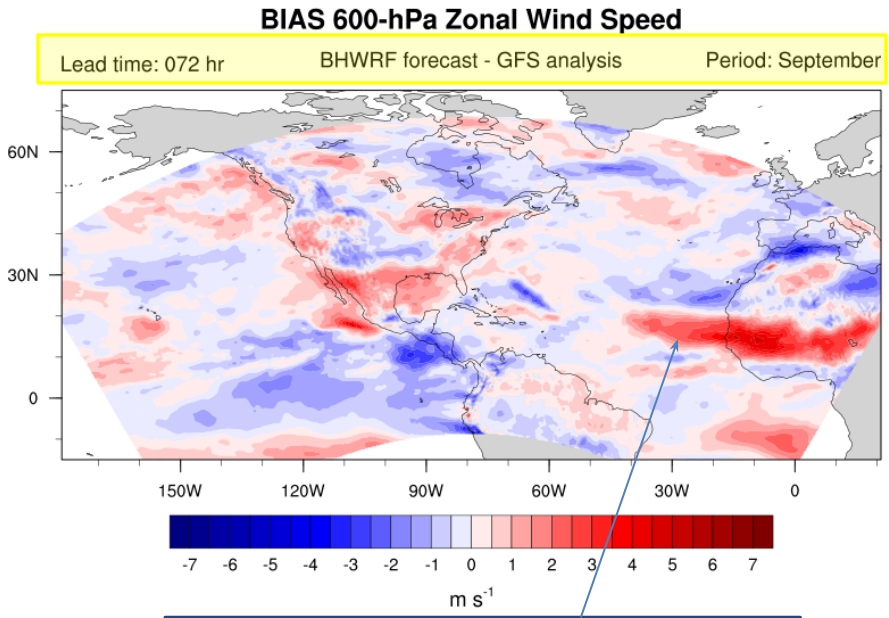


Intensity bias: modified code (HDFL) lowers intensity and helps overintensification at long lead times

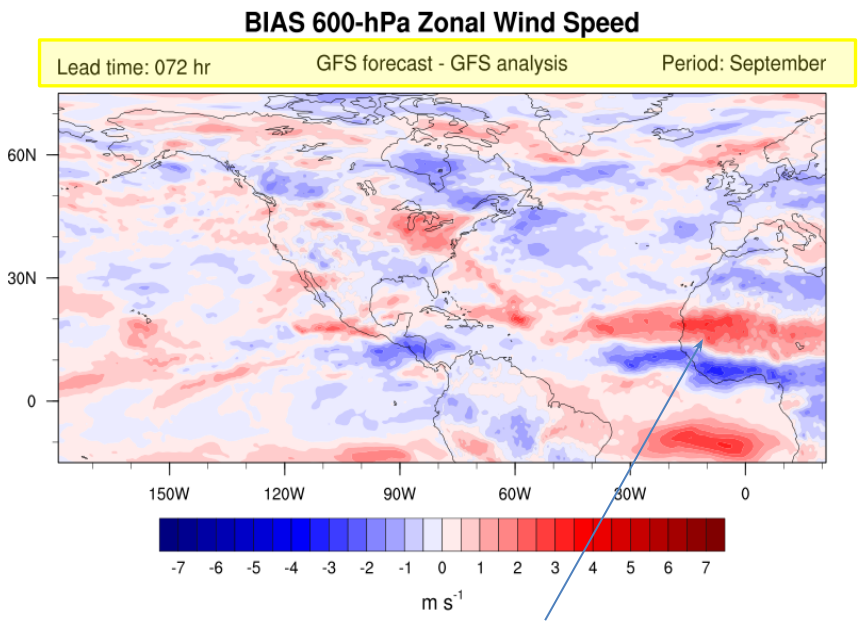
HD12 (black): DTC control
HDFL (red): DTC flux experiment

This example is the 600-hPa zonal wind bias for the 72-h forecast averaged over Sep 2011

Highlight 3: HWRF diagnostics



HWRF: African jet too weak



GFS: jet displaced to south

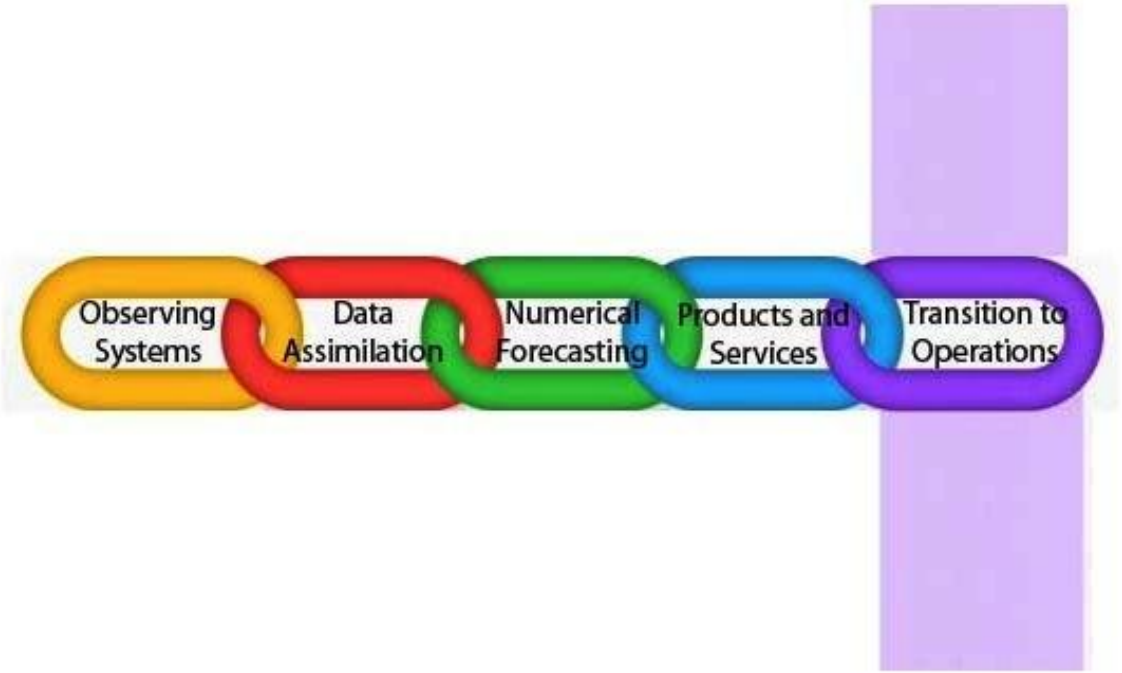
DTC compared HWRF and GFS forecasts run by NCEP against GFS analyses

- This was done for the entire 2011 season
- Results revealed strengths and shortcomings of HWRF
- Provides input for physical processes studies and priorities for development

Future direction for DTC

- How can the DTC plan ahead when planning in NOAA in general is limited and OAR-NWS coordination is limited?
  - E.g., what will hurricane NWP look like in 3-5 y?
- Where should DTC position itself in the R2O funnel?
  - Move more towards R2O for the 3-5 y timeframe?
- From limited area to global NWP?
  - Global models: future for mesoscale applications
- Technical infrastructure for R-O interactions
  - SAB suggested DTC facilitates an infrastructure for performing/archiving experiments with the operational system (similar to ECMWF IFS). A substantial new effort?

Transition to Operations



LAPS Applications:

High Resolution LAPS is used to initialize WRF model runs and other systems around the globe

RSA (Range Standardization And Automation System)

LAPS

HWS

AWIPS II

PRECISION AIRDROP

PADS

WRF WRF WRF WRF WRF WRF

Ensemble

AFTAC (Air Force Technical Applications Center)

WRF DFW

WRF SEA

WRF NYC

WRF KSC

Projects using LAPS/WRF to support dispersion models:

RSA - *Range Standardization and Automation Weather Support System*

- Personnel: Linda Wharton, Steve Albers, Isidora Jankov, Dan Birkenheuer

- Runs LAPS and WRF with cycling to provide real-time products for an AWIPS display and as input to dispersion models

Photo: Brian Webb

- Currently runs at Vandenberg AFB supporting all launches. It also ran at Kennedy Space Center

- Future: The Air Force has a contract with Lockheed Martin to complete the Western Range Mission Flight Control Center. FAB's contract runs through FY13.

- Why is it needed…?

RSA - *Range Standardization and Automation Weather Support System*

… to support dispersion models predicting where toxic plumes from rocket launches will go.

… to provide high resolution weather data to help with launch decisions.

FAB was awarded the NOAA Tech Transfer Award for RSA in 2005.

Projects using LAPS/WRF to support dispersion models:

AFTAC - *Air Force Technical Applications Center*

- Personnel: Wharton

- Provided nuclear treaty monitoring, nuclear event detection and analyzed disturbing events for nuclear identification.

- Ran a ten-member ensemble of LAPS and WRF using cycling at locations around the globe.

- Developed scripting to automatically run simulations using cycling and ingests available AFWA datasets into LAPS.

Projects using LAPS/WRF to support dispersion models:

GTAS - *Geo-Targeted Alerting System*

- Personnel: Linda Wharton, Huiling Yuan, Steve Albers, Isidora Jankov

- Initialized WRF-NMM with high-resolution LAPS and ran WRF at 4.5km with a 1.5km nest. Provided air dispersion and toxic plume information along with NOAA meteorological and environmental data to state and local emergency management agencies.

- Ran at Dallas-Ft Worth, Seattle, New York City and Kansas City. In test mode, the DFW domain was expanded to include Houston and Lake Charles to provide hurricane support.

- Future: ISB is looking for a sponsor to fund this project.

Technology Transfer Projects using LAPS:

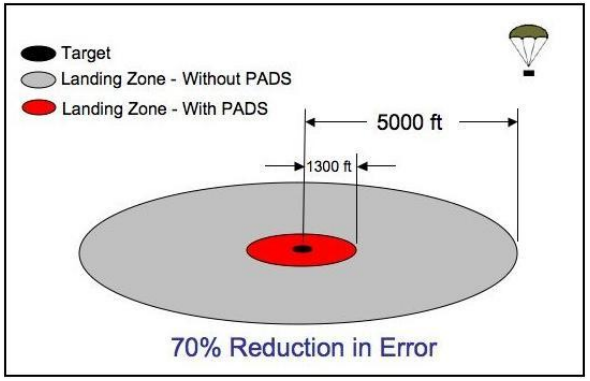
PADS - *Precision Air-Drop System*

- Personnel: Linda Wharton, Steve Albers, Dan Birkenheuer, John McGinley

- Increase wind accuracy in the LAPS wind analysis by using dropsonde wind data collected from the aircraft just prior to payload drop.

- Allows payloads to be dropped from up to 25000 ft with high accuracy.

- Reduces average distance between the center of the drop zone and the landing position from 5000 ft to 1300 ft, which is a 70% reduction in error.



- Won 2008 NOAA Tech Transfer Award.

- Currently in use by the US Military saving lives in Iraq and Afghanistan.

Technology Transfer Projects using LAPS:

ITWS - *Integrated Terminal Weather System*

- Personnel: Steve Albers, Dan Birkenheuer

- Developed in collaboration with MIT/LL and Raytheon to develop ITWS T-LAPS, providing real-time predictive weather impact decision aids for weather such as microbursts, storm cell information and terminal winds.

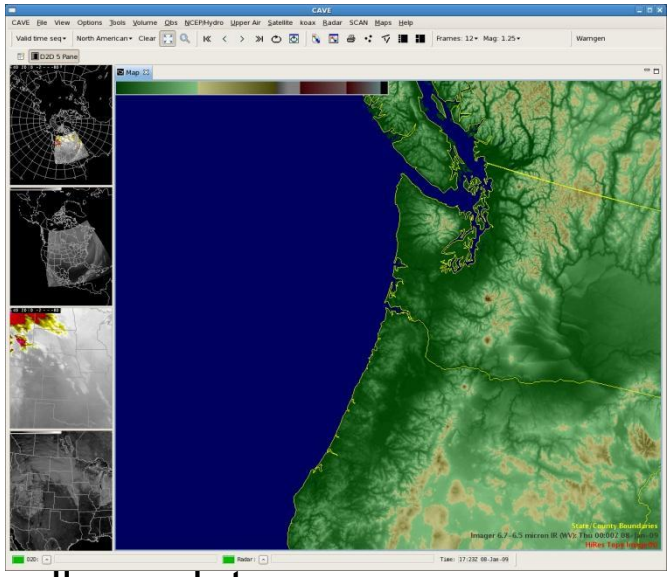
- In use at 40 ITWS sites across the US.

- Provides impact decision aids for Pilots, Air Traffic Controllers Traffic managers.

- Delivered to Raytheon.

Technology Transfer Projects using LAPS:

AWIPS II



- Personnel: Paul Schultz,
  Linda Wharton, Steve Albers,
  Dan Birkenheuer, Paula McCaslin,
  Kirk Holub

- LAPS has been in AWIPS since its inception.

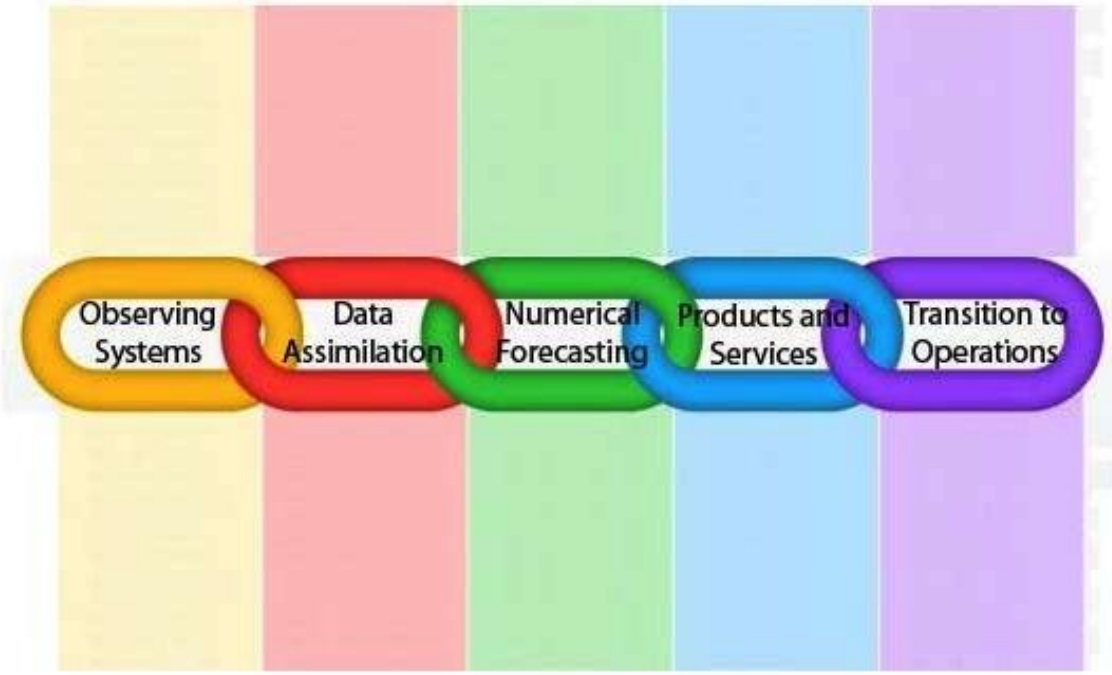
- Current LAPS in AWIPS II utilizes scripts that pull raw data from the new EDEX database and create AWIPS I format netCDF files for ingest into LAPS.

- Future: The LAPS data ingest will be modified to ingest raw data directly from the EDEX database and other data available through web-services.

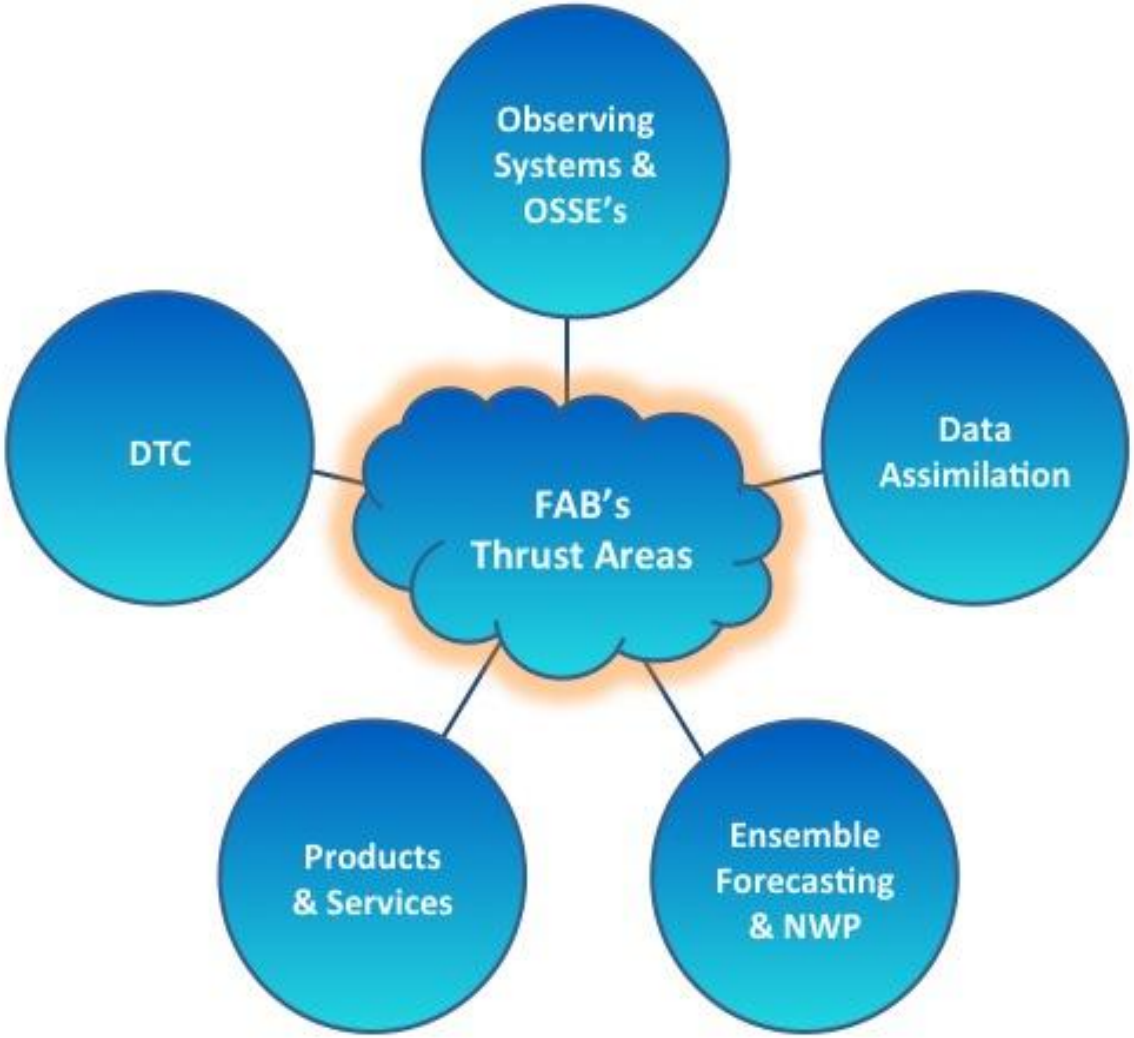
FAB(-ulous) Staff

- Brief introduction by everyone
  - Go around the room
    - Notes on recent work, etc

Summary


Observing Systems
Data Assimilation
Numerical Forecasting
Products and Services
Transition to Operations

FAB Context Diagram



Introduction (Zoltan)

- Matrix (just my note here made at during the 16 Nov meeting)
- (consider a list of people in the branch, maybe take the time to go around the room for brief introductions?)
- Strategic plan
- Thrust areas (maybe introduce the leads giving the individual presentations)
- You mentioned including FAB mission statement how it fits GSD's
- Zoltan might consider showing the next slide as part of his talk... our web page.

GPS Backup Slides

The following slides came from the GPS Met section.
#31 -> #124

GPS Observations

NOAA Mission:
To understand and predict changes in Earth's environment and conserve and manage coastal and marine resources to meet our nation's economic, social, and environmental needs

Climate Goal:

Weather & Water Goal:

Commerce & Transportation Goal:

Satellites
Modeling & Observing Systems

GPS-Met supports NOAA's Mission by providing reliable and accurate refractivity & moisture estimates at low cost under all weather conditions anywhere a permanent GPS tracking station can be established.

Demonstrating that Knowledge of TPW can Improve the Satellite Thermal Sounding Retrievals

- Data sensitivity test by perturbing the moisture profile of the input sounding.
- Computed the K-matrix for the subsequent **Thermal** channels

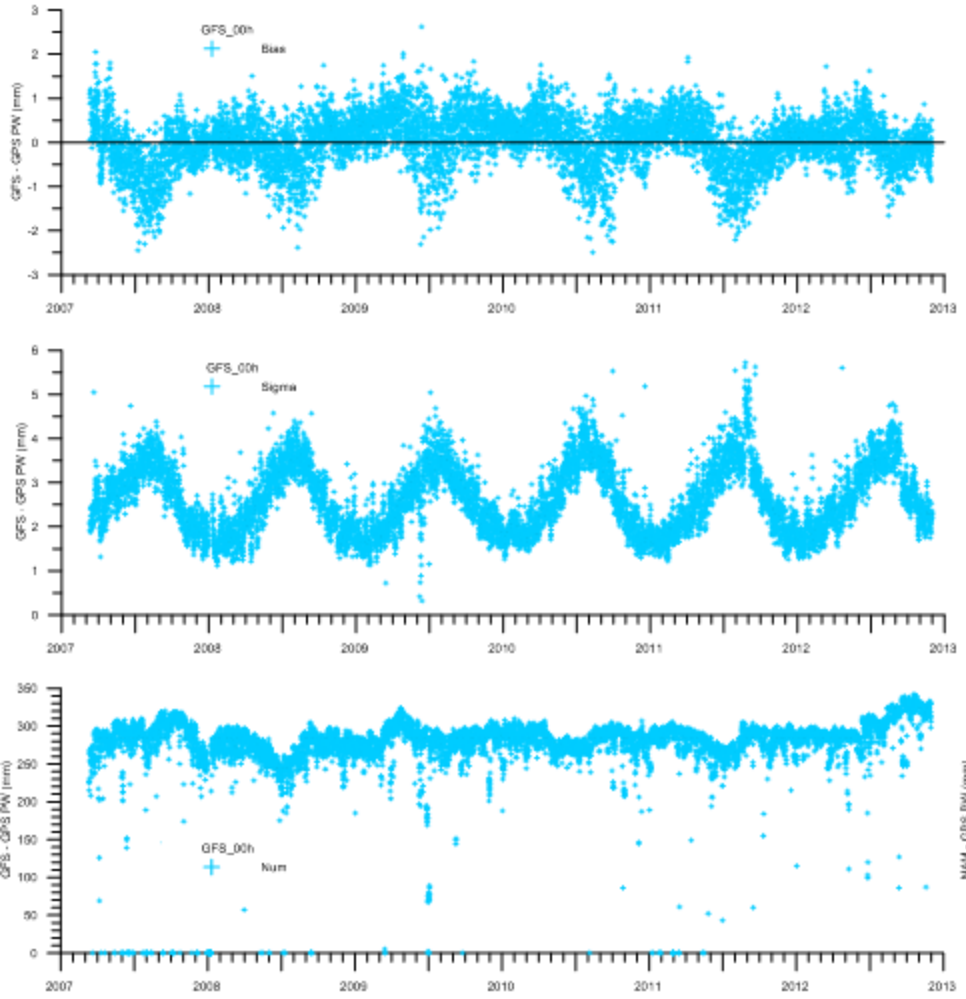
- Ran thousands of soundings through the system perturbed and unperturbed and assessed the degree of impact on the radiances for each channel.

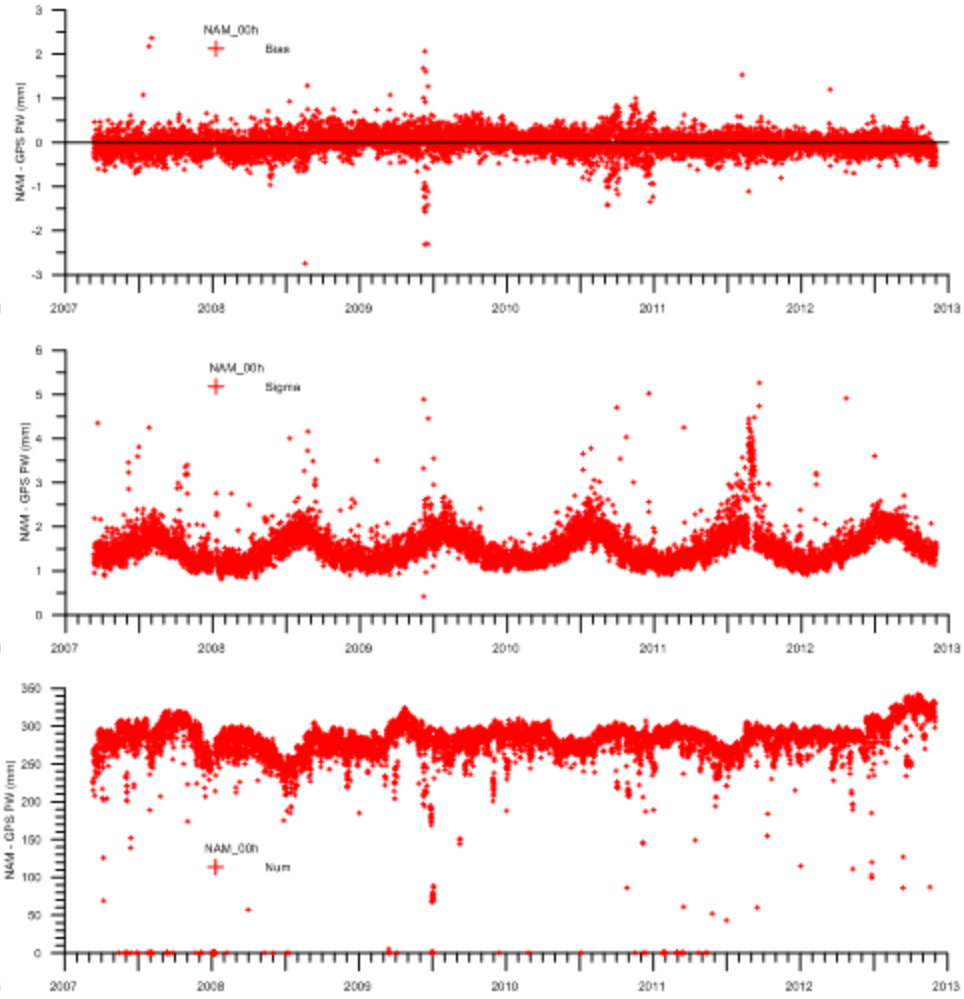
- Took the radiance differences and using the K-matrix, assessed the impact to the **Thermal** profiles.

- Results show that current GOES thermal retrievals can improve with improved knowledge of moisture.

- Additionally **GOES R will benefit more** from knowledge of the TPW (by a factor of about 3) than the current GOES.

Long-term PW Differences

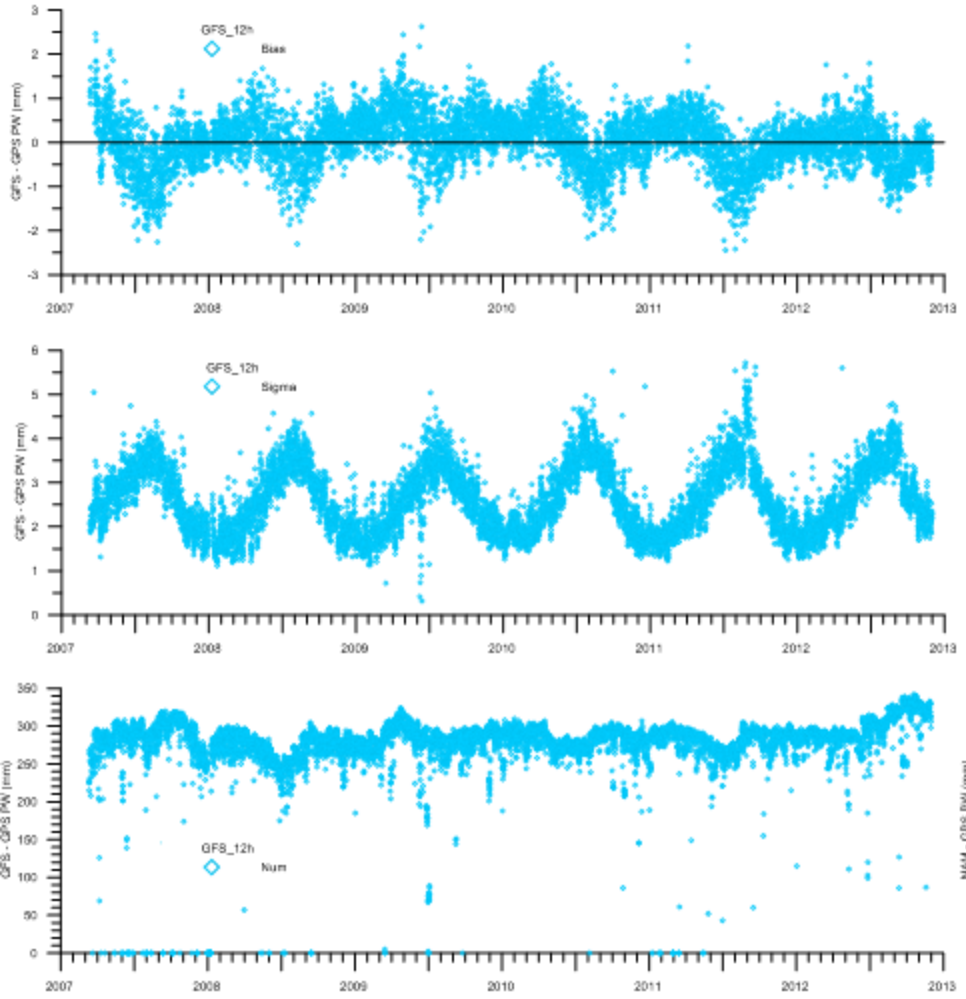


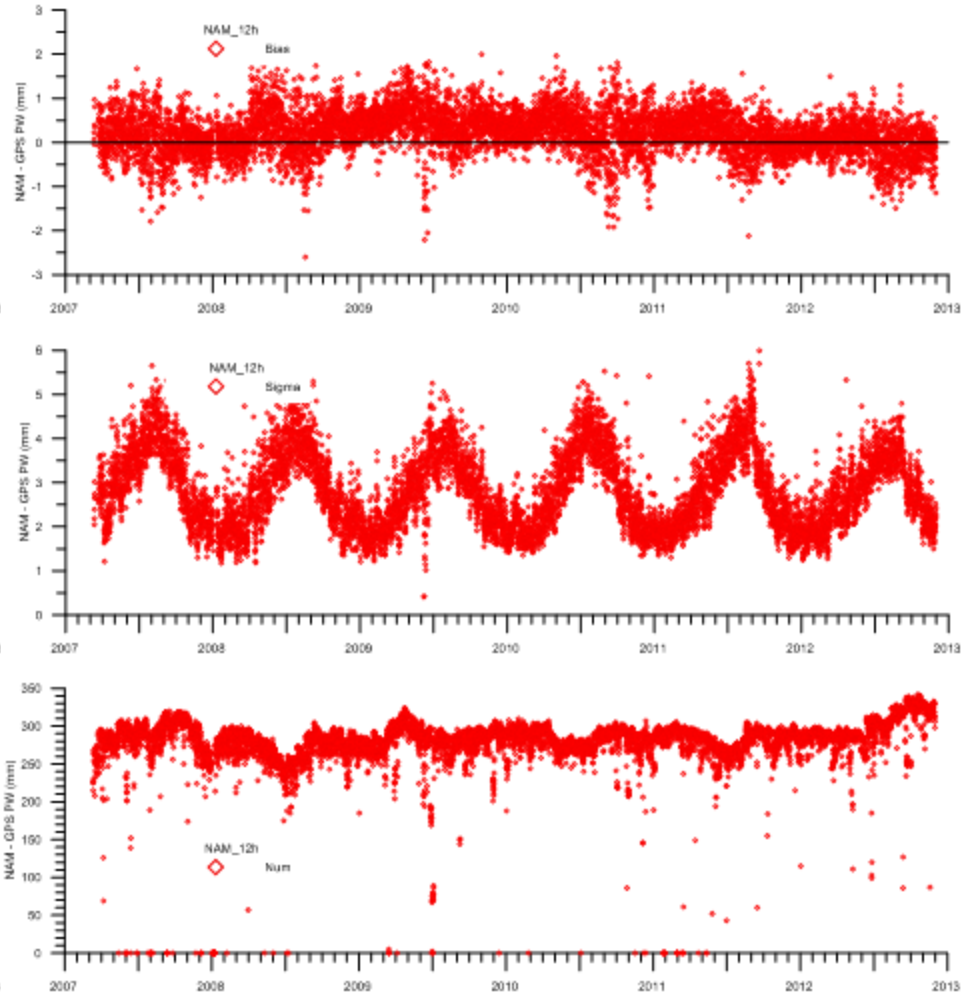


GFS PW Analysis (valid at 0, 6, 12 & 18 UTC) - GPS observations

NAM PW Analysis (valid at 0, 6, 12 & 18 UTC) - GPS observations

Long-term PW Differences



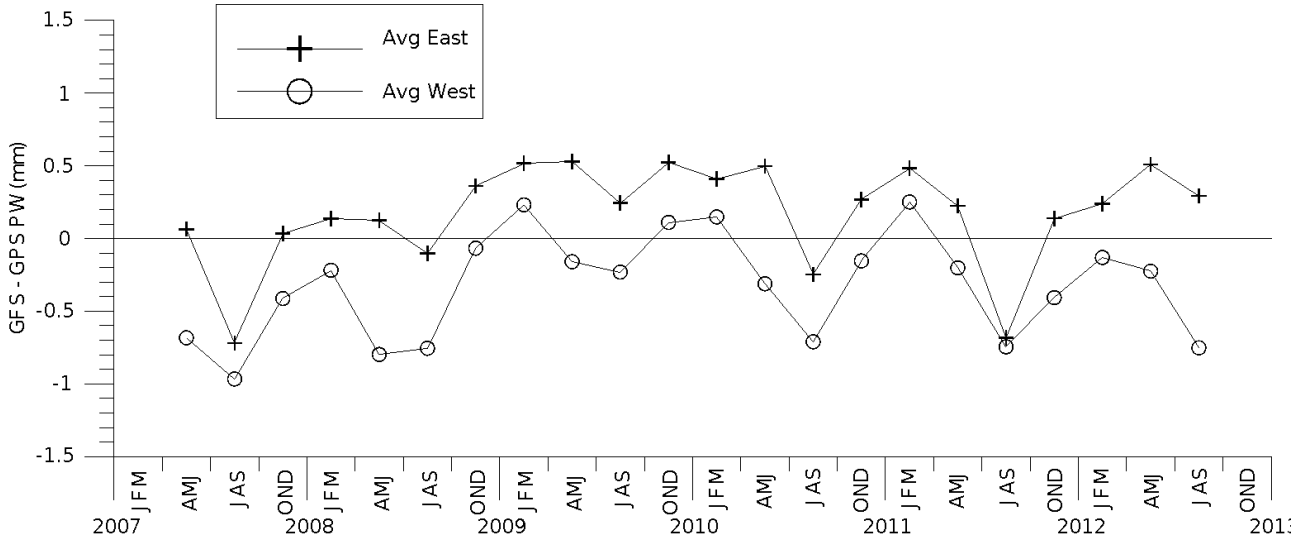


GFS 12-h PW Fcst (valid at 0, 6, 12 & 18 UTC - GPS observations

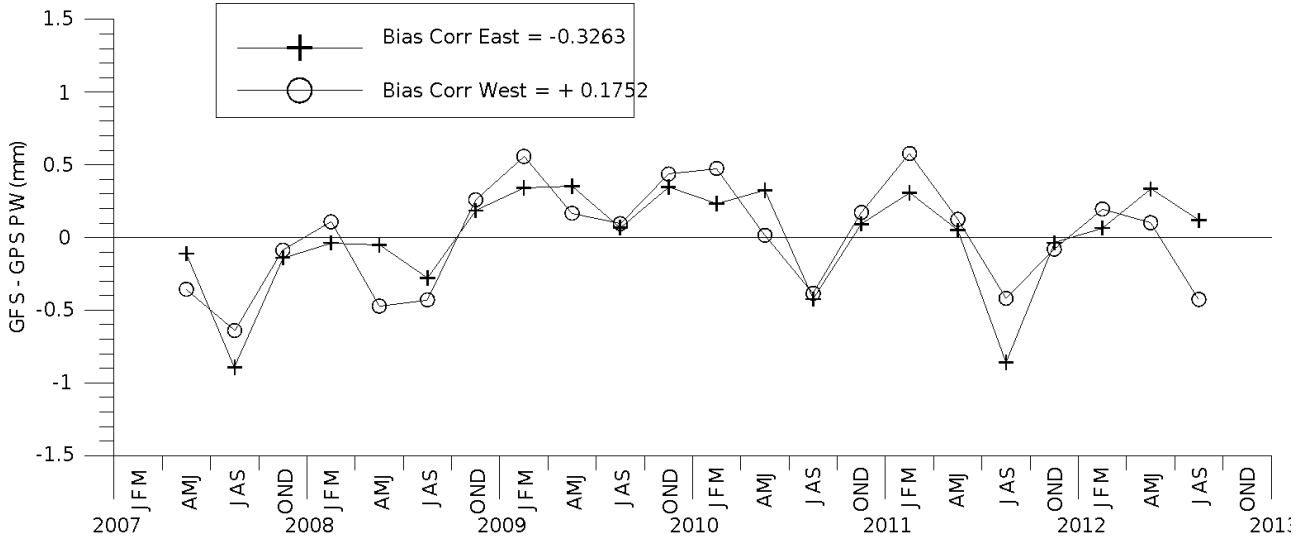
NAM 12-h PW Fcst (valid at 0, 6, 12 & 18 UTC - GPS observations

Disentangling NWP Model Uncertainty

Seasonal average (GFS – GPS) TPW differences



No bias correction



bias-corrected

Programmatic Issues

- Transition of GPS Met from research into operations is stalled.
  - Delays in preparation of decision documents for LOTM caused by several factors including reassignments of key personnel;
  - A “home” for the observing system (DAPS & Field Segment) has not yet been identified
  - Funds to complete the transition or sustain it after transition have also not been identified.
- Base funding allocated for GPS Met R&D in OAR is inadequate to sustain the program at its current level.
  - FAB uses external funds just to staff the project;
  - Everything (materials and labor) are leveraged to the maximum extent possible: no margin.

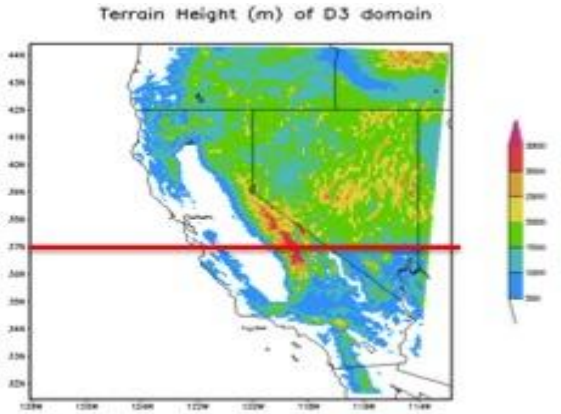
OSSE Challenges

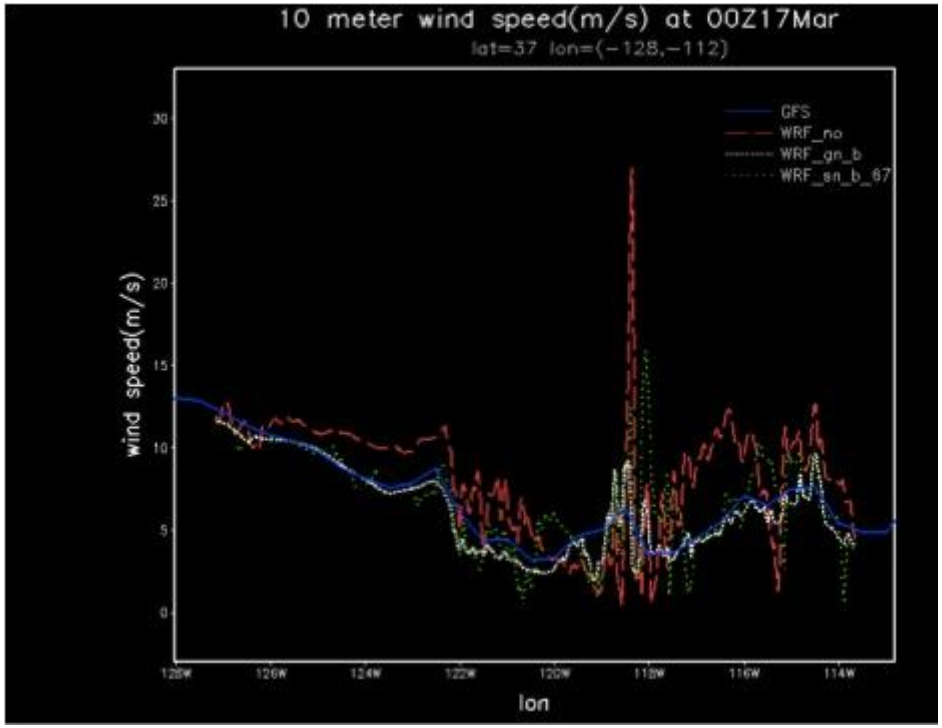
- High resolution nature run for severe weather
  - realism: cloud, storm structure and so on;
- Calibration and evaluation
  - OSSE vs. real atmosphere;
  - Observation errors, cloud representations in NR;
- Optimal future observation system design
  - Targeting observation tools in OSSE;
- Synthetic observations
  - satellite radiance data with realistic cloud

Regional High Resolution Nature Run

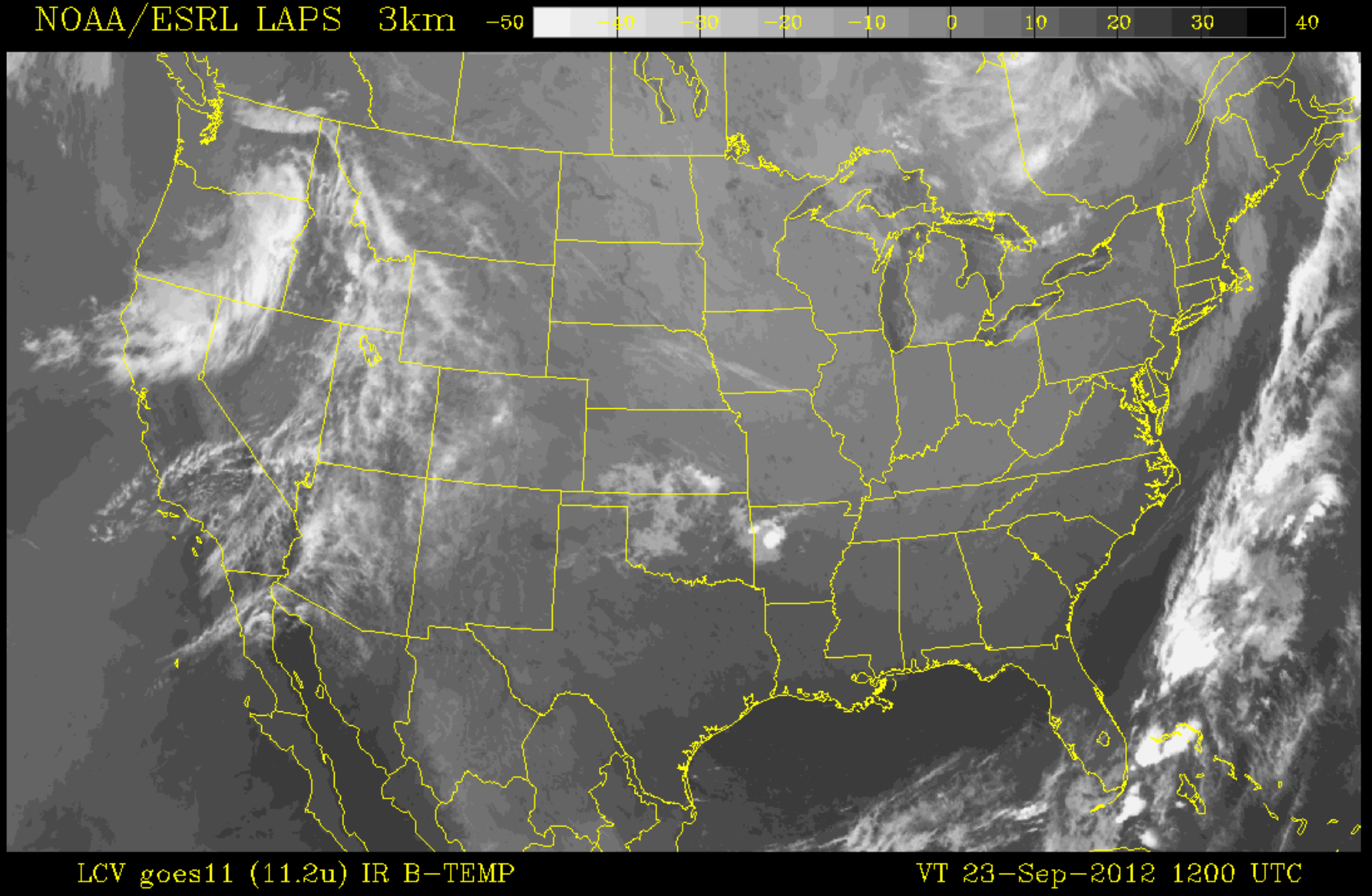
Investigation of a new high resolution nature run

- A new methodology:
  - Nudging toward analysis;
- Validation
  - Realism
  - Use of existing ensemble
  - Use of real obs





Simulated IR Satellite LAPS / WRF 6-Hr Forecast Verification



Forecast high clouds tend to be too thick

*

Future Cloud / Radiation Plans - Forecast

- Test at 1km horizontal resolution and more vertical levels
- Improve Hot-Start Elements and model microphysics
  - Testing WDM6 microphysics in WRF
  - More Variational Cloud / Moisture Analyses
  - Examine various WRF short-wave radiation options
  - Improvements in WRF Aerosols
- Add direct radiation forecast

NEW DIRECTIONS

Data assimilation

- 3- and 4-Dvar
  - Collaboration with WRF and DTC DA activities
- Global LAPS
  - Encouraging results for tropical and warm season convective systems

Ensemble forecasting

- Major expansion into probabilistic forecasting
- Coupled Data assimilation / ensemble forecasting system
  - Ensemble-based covariances for 3-4-Dvar

Finer resolution applications

- Convective initiation
  - Warn-On-Forecast
- Fire weather & Renewable Energy
  - 100s or 10s of meters resolution

Field deployment

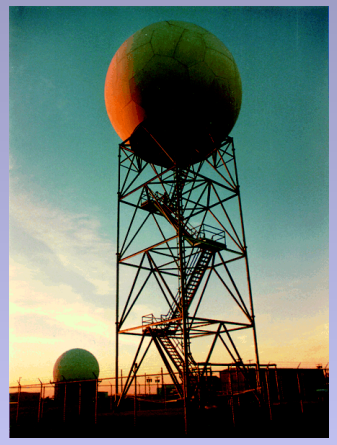
- Support incident meteorology
- Real time assimilation of field observations

Statistical post-processing

- To remove systematic errors from ensemble

LAPS Cloud analysis

First Guess →

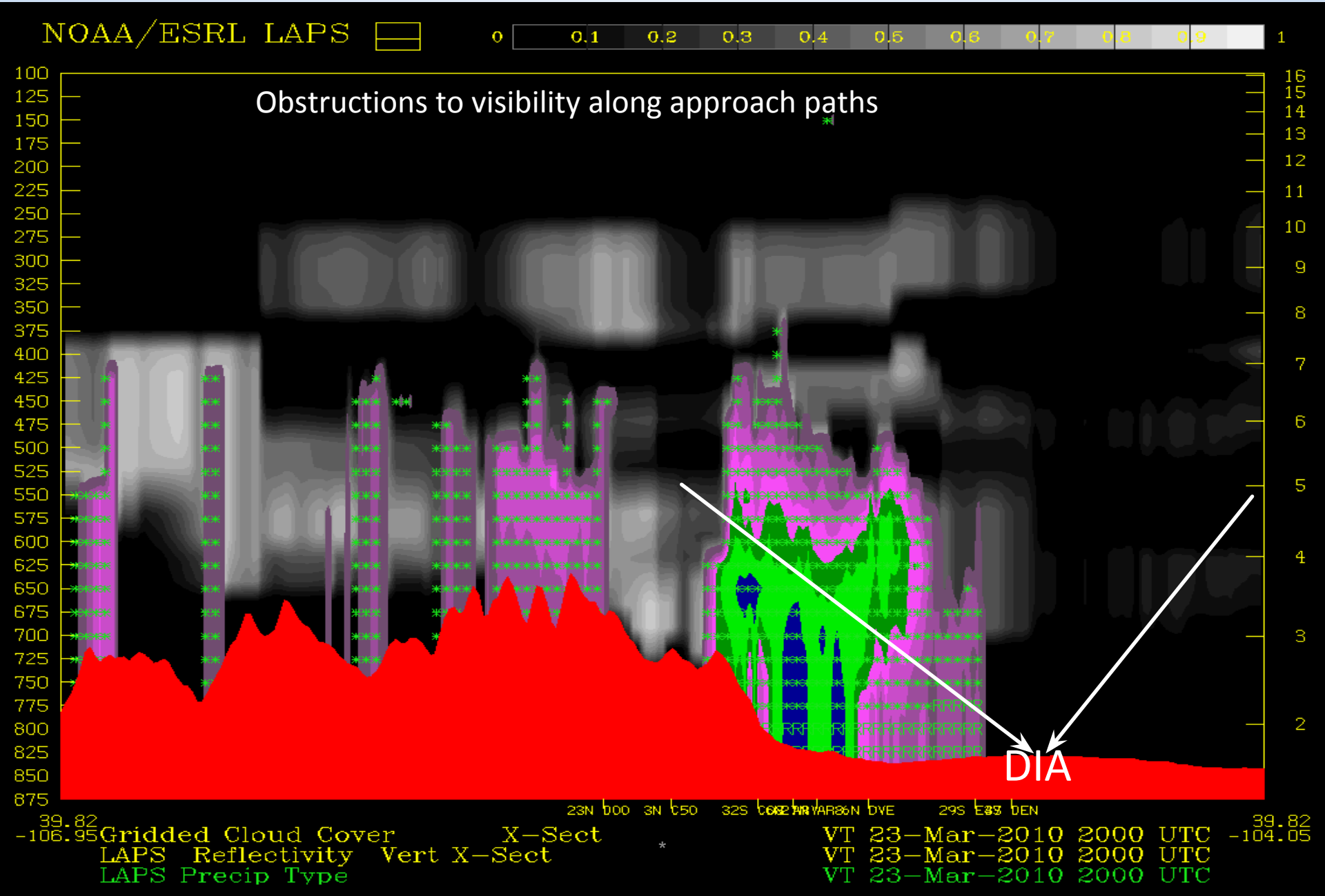


METAR

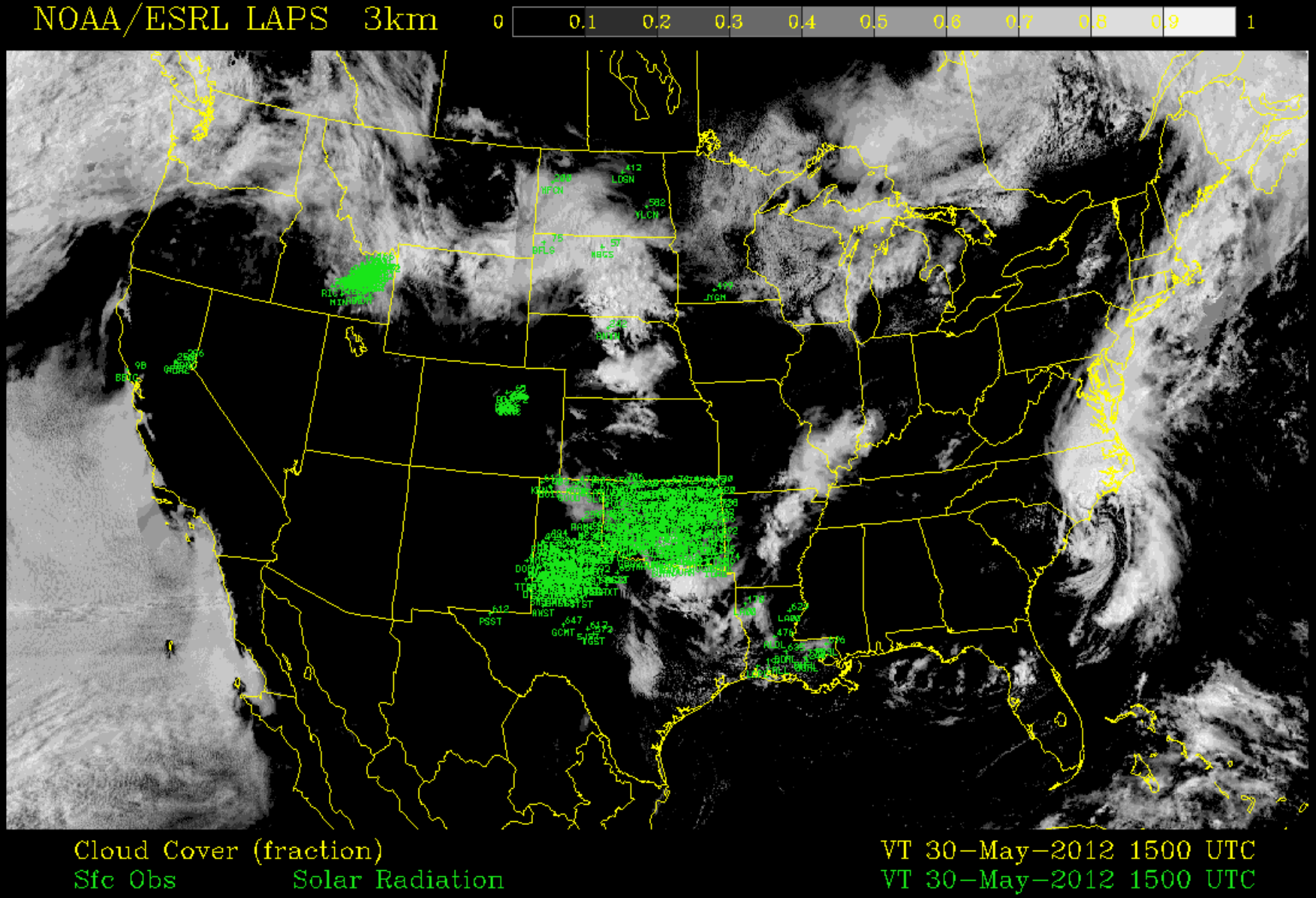
METAR

METAR

Cloud / Reflectivity / Precip Type (1km 15-min analysis)



MADIS Solar GHI Obs (<= 15min, Defined in Metadata)



NOAA/GSD/FAB -- Forecast Applications Branch - Verification

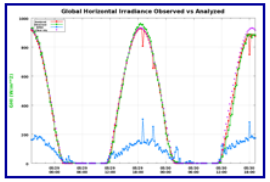
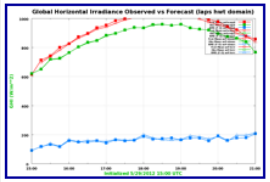
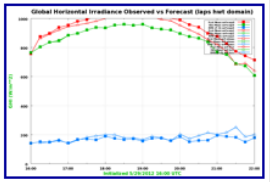
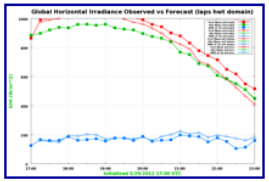
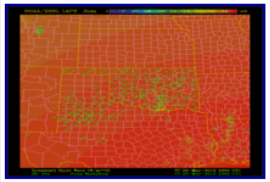
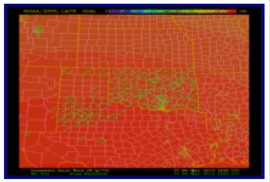
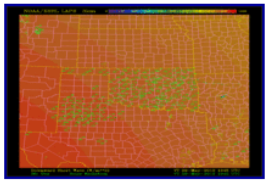
http://laps.noaa.gov/verification/swi_pt/#laps_hwt

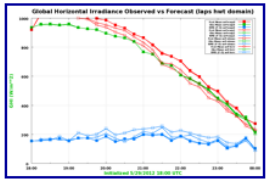
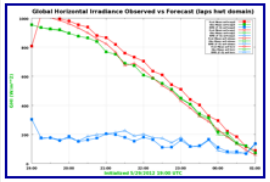
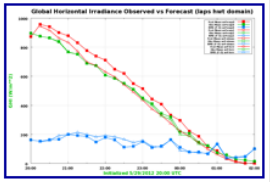
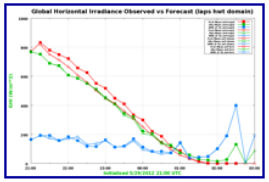
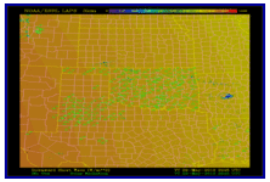
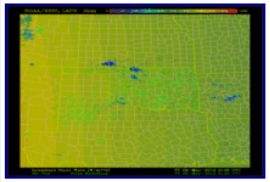
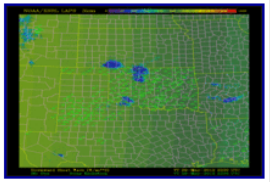
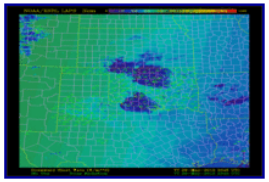
NOAA/GSD/FAB -- Forecast Appli...

laps_hwt domain

latest initialization: **121511200**

~150 Oklahoma/Texas mesonet stations

Analysis	1500 UTC run	1600 UTC run	1700 UTC run
Global Horizontal Irradiance	GHI Forecast	GHI Forecast	GHI Forecast
			
	 Montage	 Montage	 Montage

1800 UTC run	1900 UTC run	2000 UTC run	2100 UTC run
GHI Forecast	GHI Forecast	GHI Forecast	GHI Forecast
			
 Montage	 Montage	 Montage	 Montage

Analysis Images | Fcst Images (Data=Solar) | Log Output | Archive

Done

Solar Radiation Web Page

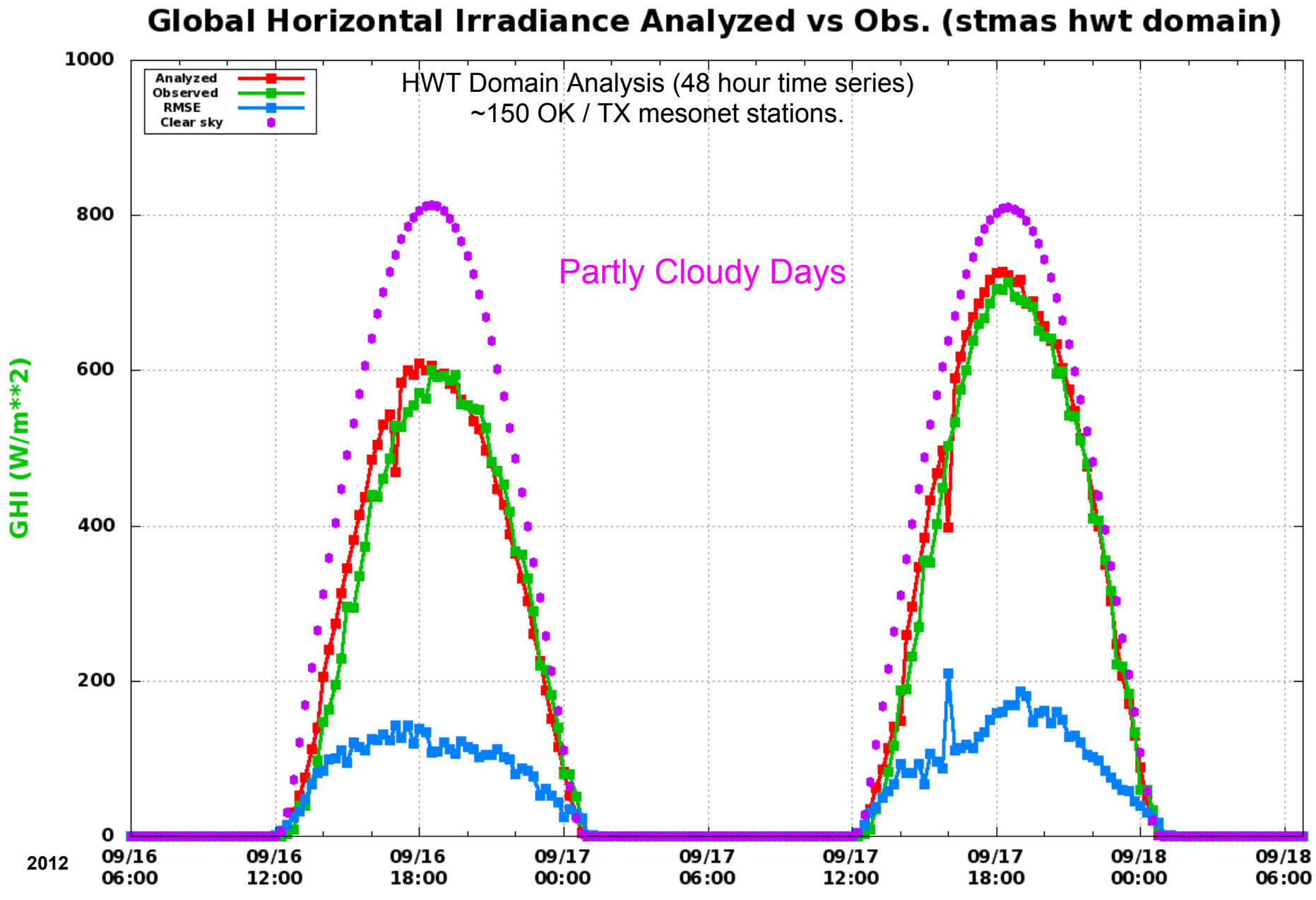
Verified at station locations measuring global solar radiation on time scales <= 15min

Mean Analyzed / Forecast

Mean Observed

RMS differences

Solar Radiation Analysis (GHI) Verification



Global Horizontal Irradiance (GHI) Forecast

- **Generated from LAPS initialized WRF model**
  - Uses WRF Downward Short-Wave Radiation Output
  - Dudhia Short-Wave Scheme
  - Thompson Microphysics
- **"Hot-Start" procedure used to help get clouds into model**
  - Vertical Velocity / Horizontal Divergence
  - Temperature / Height Adjustment
  - Hydrometeor Assimilation
  - Consistent Water Vapor Fields

Cloud / Radiation Plans - Analysis

- Develop forward models for all data sources being used to more fully implement a variational approach
  - Set up constraints based on model microphysics and radiation packages (e.g. CRTM)
    - Will allow assimilation of pyranometers
    - May require improved consistency between these packages
    - Test using present algorithm as a benchmark

- Improve analysis radiation model to handle direct radiation
  - Start with simple model that can use clouds and aerosol optical depth (if available)

- Consider wavelengths of solar radiation measurements and PV arrays

Explanation of Box Plots